

Thesis for the Degree of Doctor of Medicine.

UNIVERSITY OF  
EDINBURGH  
RADIOGRAPHY  
University

of

Edinburgh.

John James Stevenson, M.B., Ch.B., D.M.R.

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## INTRODUCTION.

Since Body Section Radiography, now generally known as tomography, has become a very large amount of literature has grown around this subject. THE DEVELOPMENT OF  
BODY SECTION RADIOGRAPHY  
has been written on this subject by MacDonagh and Weinbren, who give a general account of its development, but do not attempt an exhaustive technical survey. Apart from these two authors and TO ITS APPLICATION  
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In my Radiological practice tomography is employed to a considerable extent as a method of investigation. About two years ago I heard that a new method for obtaining horizontal body sections by radiography was being carried out in Italy.

It was that an apparatus for this purpose had been constructed in England in 1939, and following trials in several hospitals had produced disappointing results. Suspecting that the latter



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The Medical Supply Association, Ltd., kindly placed their apparatus at my disposal, and having worked out the principles, this never having been properly done before, I was able to produce radiographs of horizontal sections of the thorax of good diagnostic quality and far surpassing the results previously obtained.

It is the purpose of the first part of this Thesis to consider briefly the history of Tomography together with the principles involved and its role as a diagnostic procedure. The second part deals with the history of its developement in the horizontal plane. The apparatus which I am using is described in detail and the technique of its employment is given. Finally, after describing the anatomical features shown in the normal thorax by this method, a number of cases of interesting intrathoracic lesions are demonstrated.

## DEFINITION.

Body: Section Radiography is a generic term embracing Lanthanography, Planigraphy, Tomography and Angiography. Its purpose is to project upon an x-ray film a section of a solid object. This is carried out in practice by placing out or diffusing the beam of x-rays above and below the desired level in the body, in order that objects of interest shall be rendered visible.

Part 1.

During the early years there was much controversy regarding the originator of the method, but later, as will be shown later, there is a general understanding about some of the more recent developments.

It is well known, however, that Fattig,<sup>1</sup> a French physician, took out a patent upon three practical methods in 1922, and never carried out his practice. One of them (No. 3), and its principle, is the most commonly used today. Three months later Fortes and Chausse<sup>2</sup> took out a patent on a method similar to one of Fattig's for application in deep

### DEFINITION.

Body Section Radiography is a generic term embracing Laminagraphy, Planigraphy, Tomography and Stratigraphy. Its purpose is to project upon an x-ray film a section of a solid object. This is carried out in practice by blurring out or diffusing the images of planes above and below the desired level in the body, in order that objects on that plane alone shall be rendered as sharp images.

### HISTORY OF THE METHOD.

During the early 1930's there was much controversy regarding the originator of the method, and indeed, as will be shown later, there is a measure of misunderstanding about some of the more recent developments.

It is now clear, however, that Bocage,<sup>4</sup> a French engineer, took out a patent upon three theoretical methods in 1922, but never carried them out in practice. One of them (No.3), the Planigraphic principle, is the most commonly used to-day. Three months later Portes and Chausse<sup>16</sup> took out a patent on a method similar to one of Bocage's for application in deep x-ray/



x-ray therapy.

In 1929, Kieffer,<sup>14</sup> without knowledge of Bocage's work, took out a United States patent on the Laminagraph. Unfortunately his first model was not constructed until 1936.

The honour of being the first to apply the method must be accorded to Vallebona,<sup>20</sup> who in 1930 devised a method for "the dissociation of shadows in the skull." He later called this method Stratigraphy.

Ziedses des Plantes<sup>28</sup> claims to have invented the method in 1921, but his first published work on the subject was in his thesis for his Doctorate degree in 1931. This was the practical application of one of Bocage's principles, but at that time represented the most advanced technique actually practiced. Also in 1931, Bartelink<sup>3</sup> described his results and apparatus. The latter was in many ways similar to a developement of Vallebona's original, but, as will be shown later, suffered from inherent defects which made the projection of a plane impossible. In 1935 Grossmann<sup>11</sup> introduced the term "Tomography". His apparatus, which was a modification of those previously described, became known under the trade name of "Tomograph".

The/

The above represents what can be called the fundamental work in Body Section Radiography, and it may be opportune to pause for a while to examine each method, and to consider the principles involved.

### GEOMETRY.

As has been stated, the object of the method is to obtain a sharp image of a single plane of the body with blurring of images above and below this level. This can be carried out by certain movements of the tube and film or of the patient and film.

Now the blurring of the unwanted images can be carried out in two ways:

1. By their unequal magnification on the film during the exposure.
2. By their images occupying different positions on the film during the exposure.

Conversely, if certain objects are equally magnified and their images occupy the same position on the film during the exposure, they shall be sharply defined on the film.

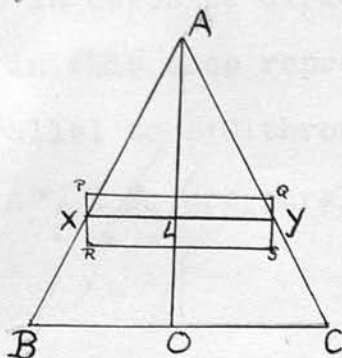


Fig.1.



Fig. 1. represents an x-ray tube irradiating an object P Q R S, with the film situated below it at B C. X Y represents the plane in P Q R S of which it is desired to obtain a radiograph. The tube and the centre of the film carriage are connected by a lever A O, pivoted at L on the plane X Y.

Obviously if an exposure were made with the above layout superimposed images of all objects in P Q R S would be cast on the film.

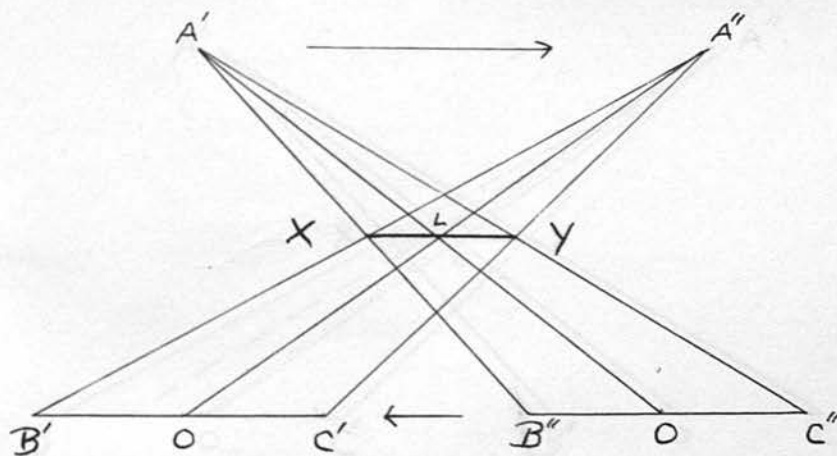


Fig. 2.

Fig. 2 represents the positions occupied by the tube and film at the beginning and end of the exposures. It will be noted that the tube and film move in opposite directions in parallel planes. X Y in this case represents the limits of a plane parallel to B'C' through L.

Since A' A'', X Y, are parallel to B'C' and B'' C'' /

B" C".

The ratio  $A'' X : A'' B' = A' X : A' B'$

Thus, the magnification of an image of an object at X, is equal on the film at the positions of the tube A' and A".

It can similarly be shown that all objects on X Y are equally magnified on the film for all positions of the tube, and as the pivot L is on the plane X Y, the shadows of all objects on that plane occupy the same position on the film throughout its travel.

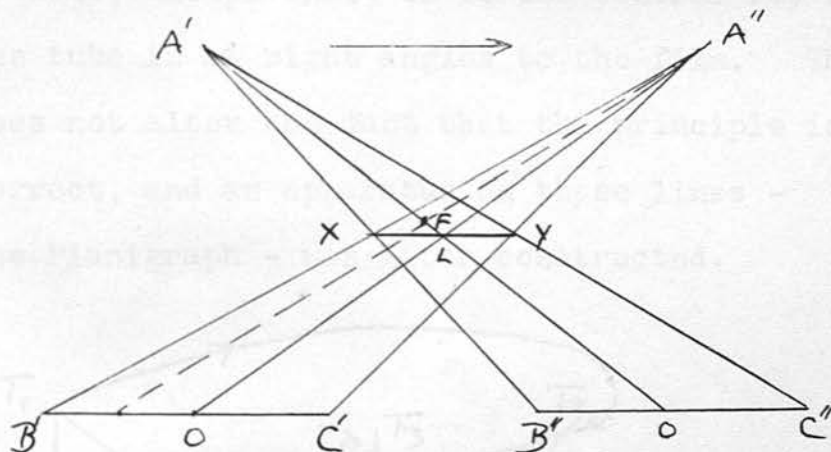


Fig. 3.

In Fig. 3 F is an object lying above the plane X Y. It will be seen that with the tube in the position A', its shadow will be thrown on to the film at O. With the tube at A'', however, it will lie between B' and O. Thus, it can be shown that all objects lying above and below X Y cast shadows which move over the film during the exposure, and if resolved at all, do /

do so as blurred images.

It will be noted that the direction of the plane selected for radiography lies parallel to that of the film. This is of fundamental importance.

#### METHODS OF BODY SECTION RADIOGRAPHY.

##### BOCAGE.

Fig. 2 represents the first of Bocage's methods, except that, in it the central ray from the tube is at right angles to the film. This does not alter the fact that the principle is correct, and an apparatus on these lines - The Planigraph - was later constructed.

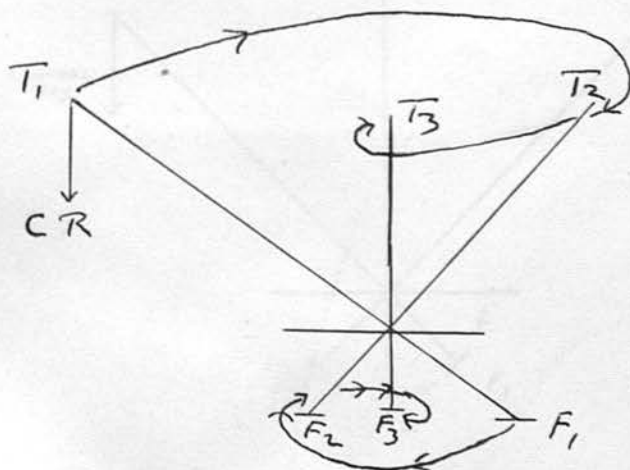


Fig. 4.

Bocage, No.2. After Andrews.<sup>1,2</sup>

Bocage's second method (Fig. 4) was similar to/

to the above except that the tube and film moved in circles or spirals. This can be shown to give correct results by similar means to the proof of his first method. In it the tube and film remain parallel throughout their movements. This was the method adopted by Ziedses des Plantes, except that in his apparatus, the central ray pointed at the centre of the film and not at right angles to it.

In Bocage's third method he proposed rotating the tube about an axis at the level of the plane which he wished to radiograph. It is obvious that this would not give the desired results, since the film is only parallel to the section in one position. (Fig. 5).

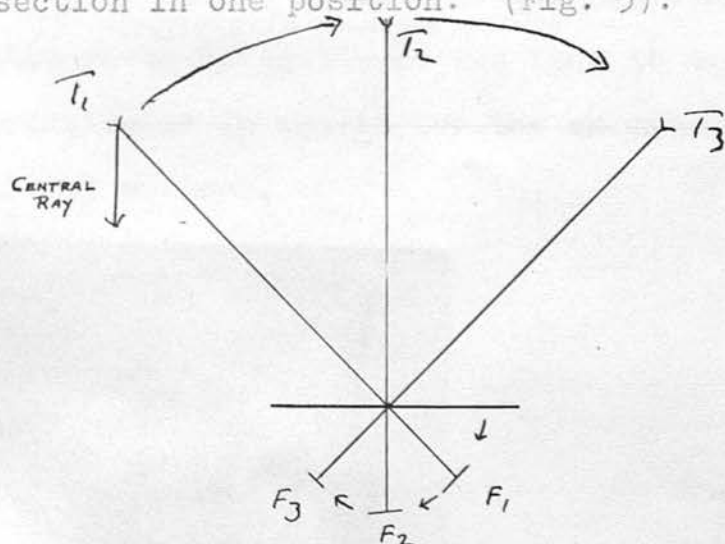


Fig. 5.

Bocage, No. 3. After Andrews.<sup>1,2</sup>

It was the above method which Portes and Chausse suggested in relation to deep therapy.



VALLEBONA.

Vallebona's first apparatus consisted of a platform, capable of swinging at an arc of a circle with a baseboard on which the cassette rests. (Fig. 6.) The tube is stationary and points downwards with the central ray directed at the centre of the film. In his first experiments he used a dried skull which was swung on the platform. While the results simulated sections, nevertheless, only the central portion was "in focus", objects near the periphery being unequally magnified during the exposure. Also, the plane of the desired section did not remain parallel to the film. Another disadvantage of this piece of equipment was that it was not practicable to use it for the examination of the living patient.

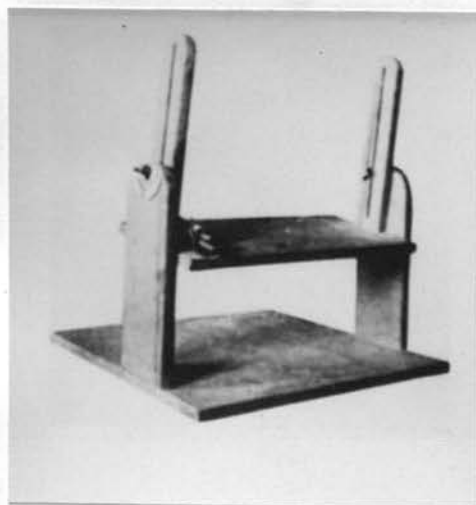


Fig. 6.

Vallebona's  
First  
Apparatus.



Vallebona's second apparatus, Fig.7 consisted of a rigid arm connecting the tube support and cassette platform. The arm was pivoted about a point which could be raised or lowered according to the section desired. With this apparatus the patient could lie on a couch with the tube above him and the cassette underneath. During the exposure the tube and film moved in opposite directions in an arc of a circle. As in his first apparatus the principle is incorrect because the film does not remain parallel to the plane of the section. However, objects near the centre of the field could be shown with reasonable clarity.



Fig. 7.  
Vallebona's  
Second  
Apparatus.

In Vallebona's third apparatus, Fig.8, the patient stands on a platform which is rotated during the exposure, with the tube and film stationary/

stationary. This apparatus was only a variation of his first, and suffered from its geometrical defects.

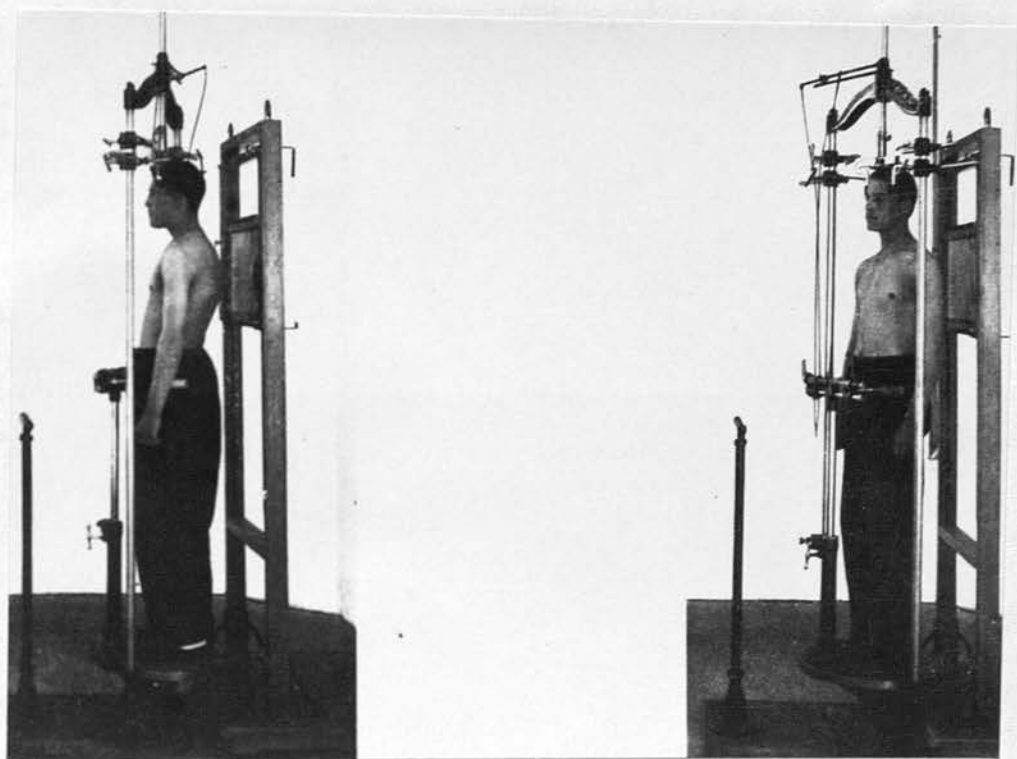


Fig. 8.

Vallebona's Third Apparatus.

It was not until after Ziedses des Plantes' and Bocage's work became generally known that Vallabona had an apparatus constructed for him which satisfied geometrical analysis. It was constructed for him by the firm of Meschia of Milan. The principle was that previously described by Bozzetti<sup>5</sup>, and consisted of rotating the patient and film through about  $30^{\circ}$  with the plane of the section at all times parallel to the film. A Potter Bucky diaphragm was used to absorb secondary/

secondary radiation. Different sections of the body could be selected by raising and lowering the curved trough which carries the patient. Although the mechanism is complicated, bulky and noisy it has given good service of 16 years, and having seen it in action in the San Martino Hospital, I can vouch for the excellent quality of the results which it produces.

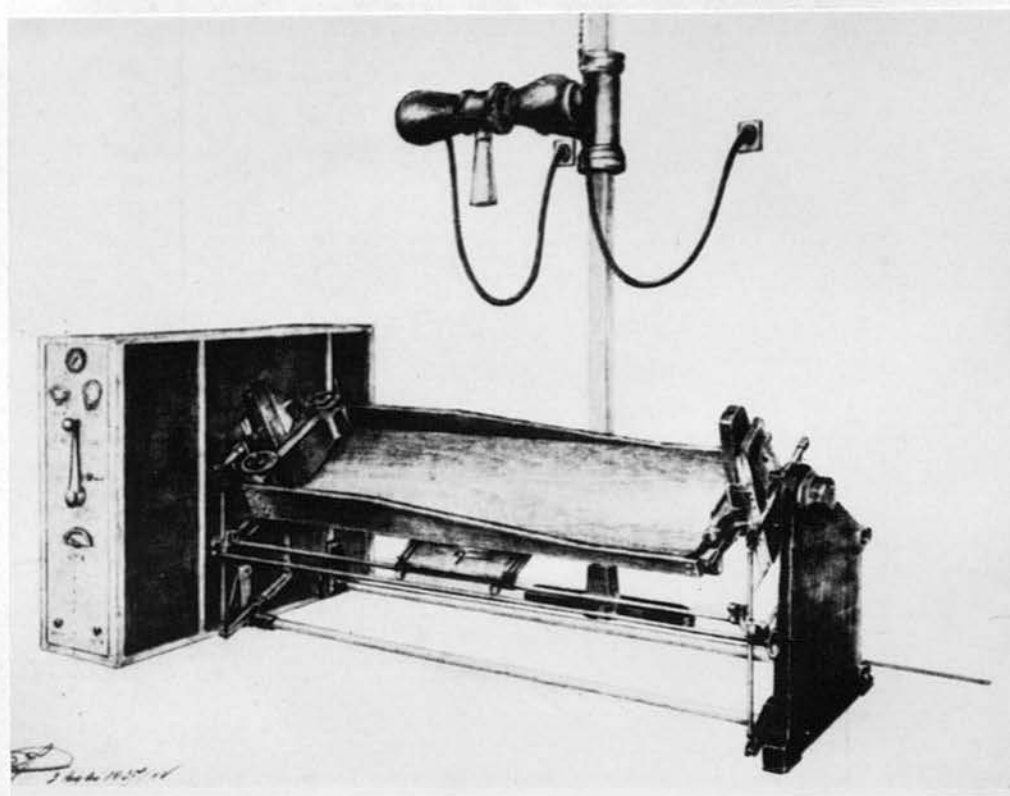


Fig. 9.

Vallebona's Fourth Apparatus.

ZIEDSES DES PLANTES.

This author's description in 1931,  
of the theoretical and practical considerations  
of/

of body section radiography was the first to date. The apparatus resulting from his calculations, Fig.10, was the first to give an accurate representation of a thin body section on an x-ray film. In it, the tube and film move synchronously in parallel planes, circles or spirals with the central ray directed to the centre of the film. As stated above this method is in accordance with the principles in Bocage's second method.

Andrews<sup>12</sup> and Kieffer<sup>13,15</sup> have shown that the pluridirectional movement of the tube and film is more effective in blurring out shadows in the layers above and below the sections, particularly those, which in unidirectional movement, are lying parallel to the direction of travel of the tube and film. The firm of Siemens and others later constructed certain models based on the principles of Bocage and Ziedses des Plantes, but with unidirectional movement of the tube and film.

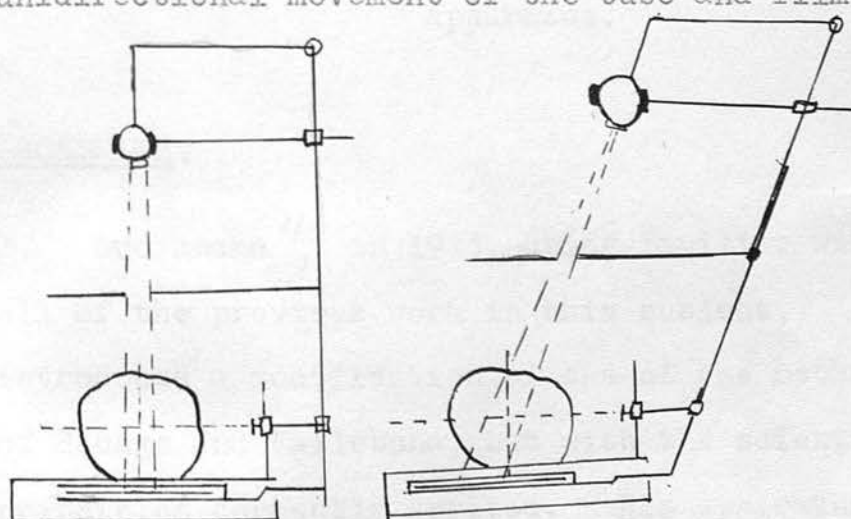


Fig. 10.

Ziedses des Plantes' Method.



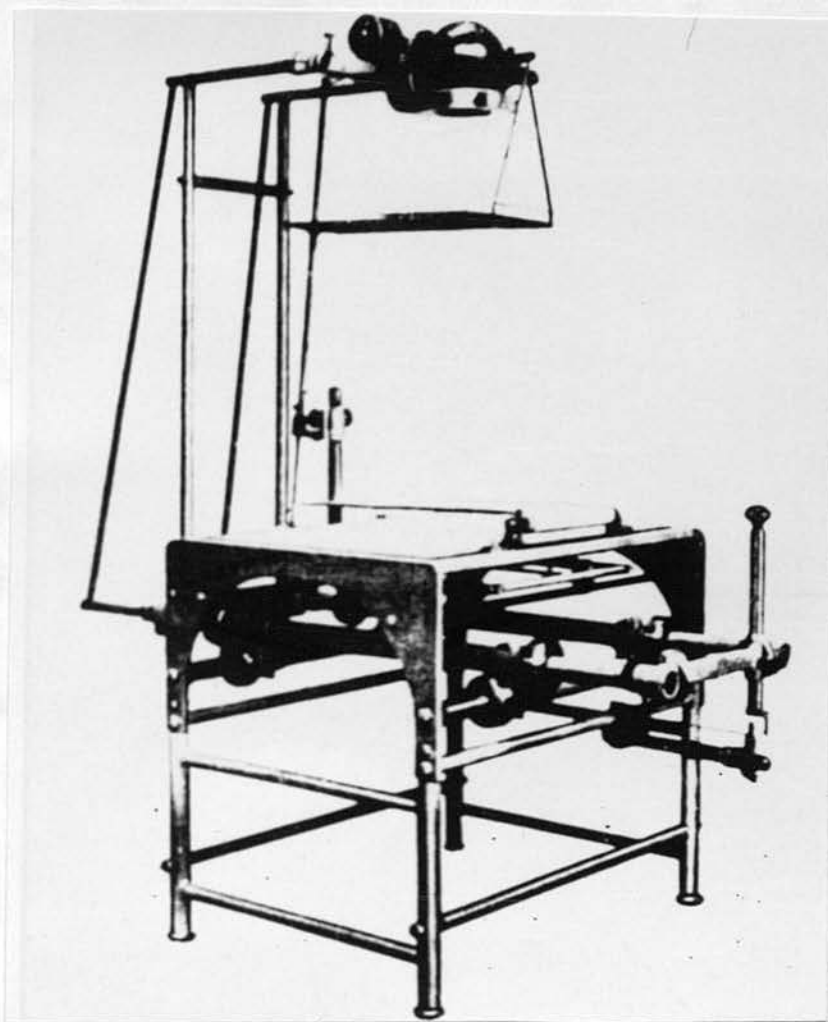


Fig. 11.

Ziedses des Plantes'  
Apparatus.

GROSSMANN.

Grossmann", in 1935, being familiar with all of the previous work in this subject, introduced a modification of one of the methods of Bocage and Vallebona, but with the scientific principles correctly applied. His apparatus employs two arms of a pendulum, rotating about an axis, the height of which is adjustable. Attached/



Attached to the upper arm of the pendulum is the tube carrier, and to the lower, is the grid, together with the film cassette carrier. The central ray is directed to the centre of the cassette. During the exposure the tube moves in an arc of a circle, while the cassette, attached to the lower portion of the pendulum also describes an arc of a circle. It should be noted that the cassette is at all times horizontal, thus differing from the method of Bocage and Vallebona.

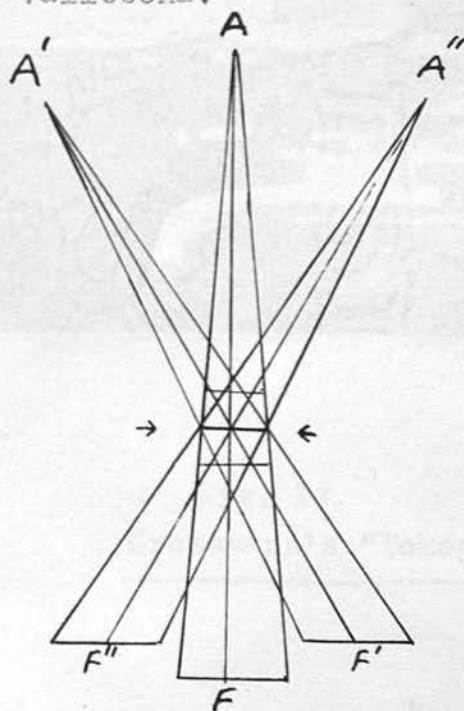


Fig. 12.

Grossmann's Method.

Fig. 12 represents in diagrammatic form the movements of this apparatus. By similar methods to those employed for Fig. 2. it can be found that/

that the principles are correct for body section radiography. The trade name of "Tomograph" was applied to this apparatus.

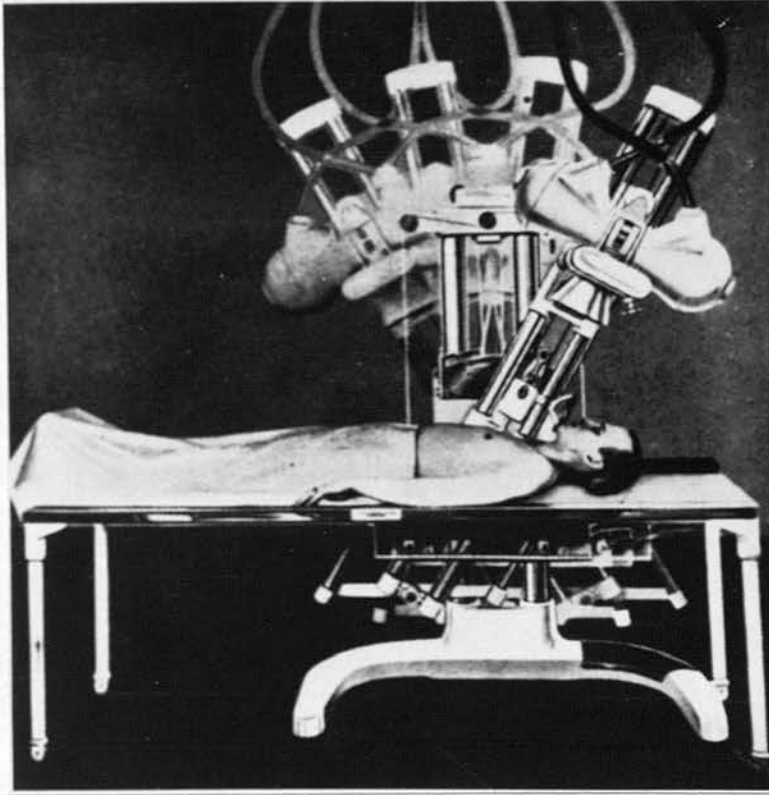


Fig. 13.  
Grossmann's "Tomograph"

This was employed by Chaoul,<sup>6</sup> in his extensive study of the normal anatomy and pathology of the thorax.

In 1937, in Great Britain, Twining<sup>19</sup> introduced a method, which, by means of a simple attachment to almost any Potter Buckey couch, it could be adapted for body section radiography. The/

The attachment consisted of a lever, mounted horizontally on a vertical axis which transmits the motion of the tube reciprocally to the film carriage. Its length is equal to the focal film distance, and its axis is variable along the length of the lever to allow for the selection of any desired plane of the patients' body. A plan of the apparatus is shown in Fig. 14.

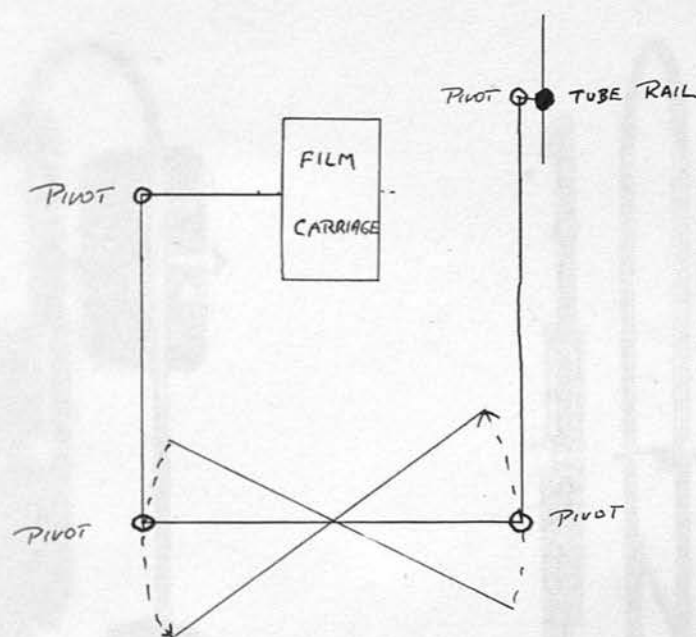


Fig. 14.  
Twining's Method

This "home made" attachment was used for many years at one of my hospitals, and has only recently been superceded by a commercial fitting, with very little difference in the results.

Bozzetti<sup>5</sup> in 1935, described a system similar to Vallebona's third method in which the patient/

patient and film are vertical. The patient is rotated during the exposure, but in this case the film also rotates. The geometry again is similar to that in Fig. 2, and the apparatus is shown in Fig. 15. It is with a similar equipment that Herdner<sup>12</sup> has carried out his examination of the skeletal system.

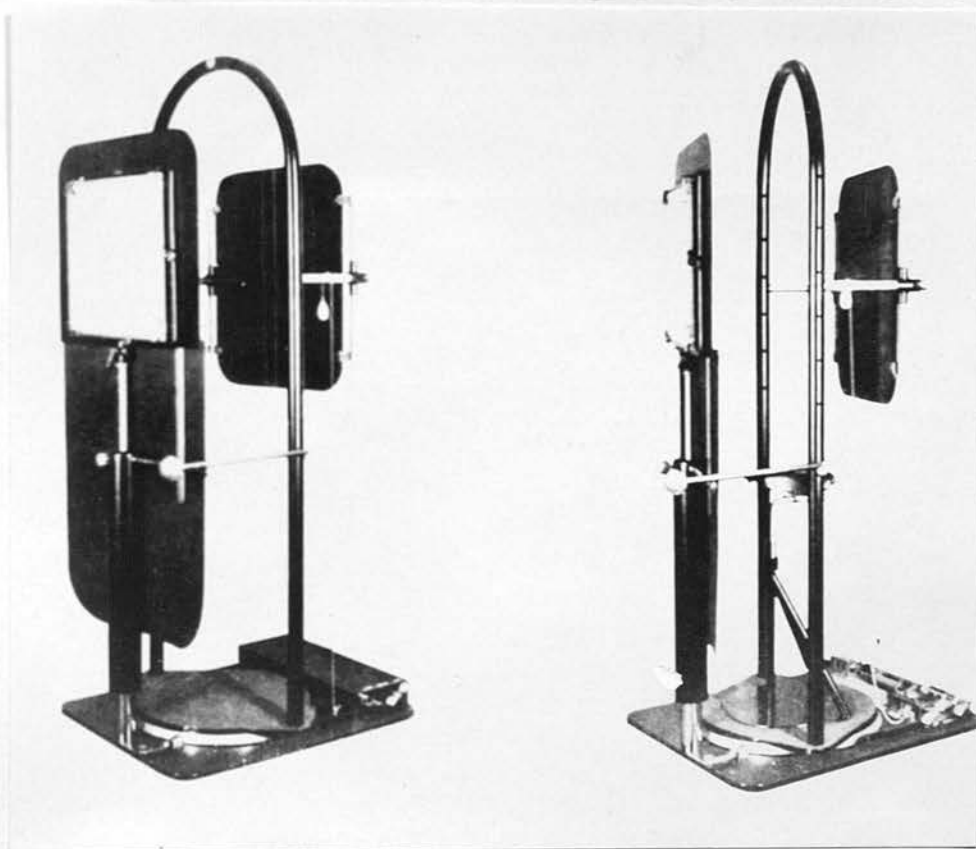


Fig. 15.

(Bozzetti's Apparatus).

The methods hitherto described are summarised in Fig. 16. (see page 18)



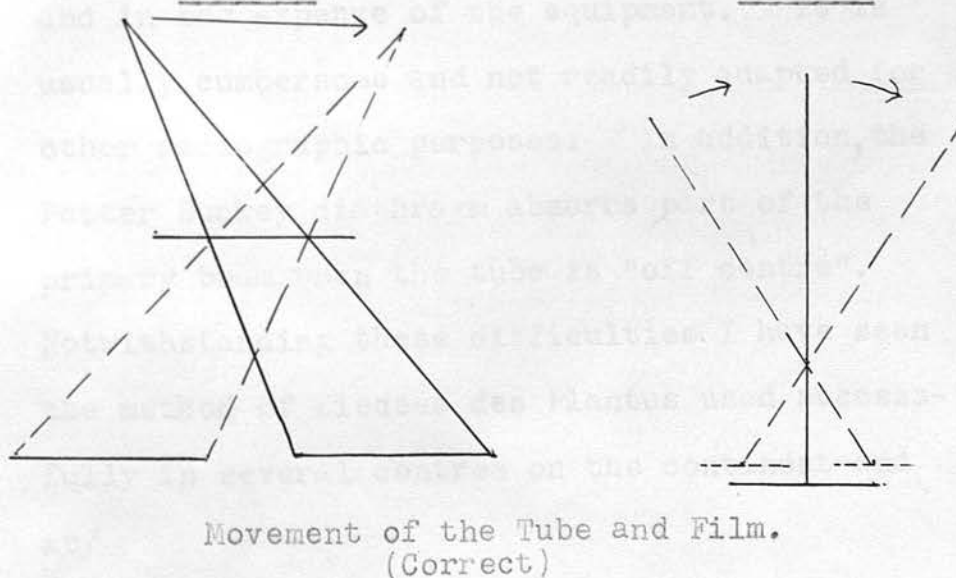
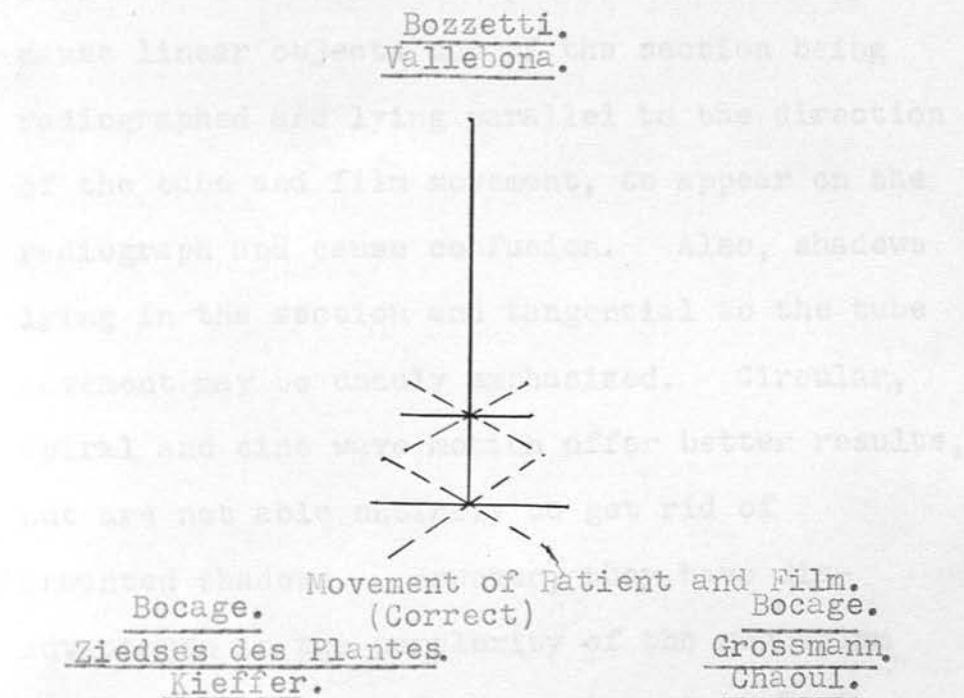
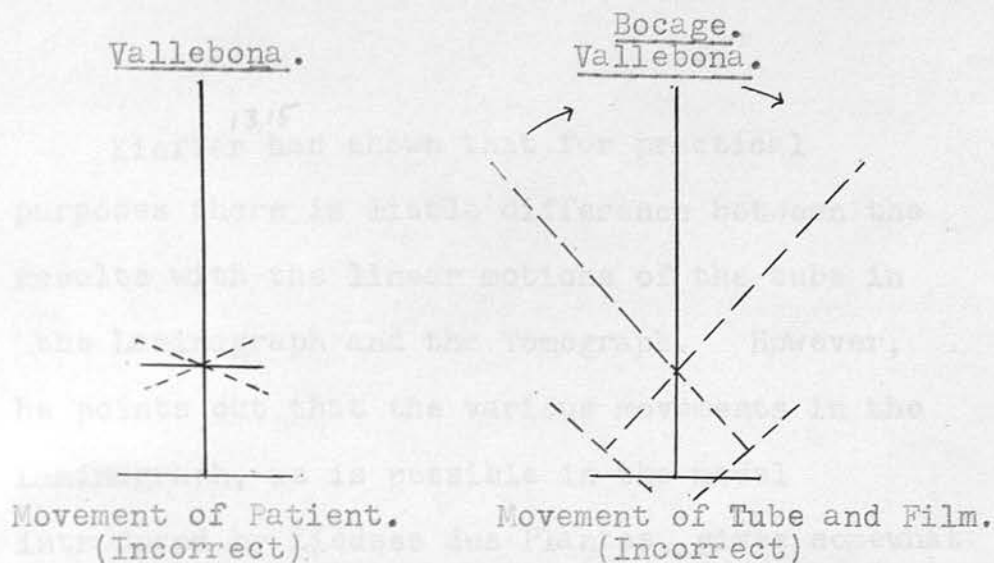


Fig.16.



<sup>13,15</sup>  
Kieffer has shown that for practical purposes there is little difference between the results with the linear motions of the tube in the Laminagraph and the Tomograph. However, he points out that the various movements in the Laminagraph, as is possible in the model introduced by Ziedses des Plantes, gives somewhat different results. Thus, linear motion may cause linear objects out of the section being radiographed and lying parallel to the direction of the tube and film movement, to appear on the radiograph and cause confusion. Also, shadows lying in the section and tangential to the tube movement may be unduly emphasised. Circular, spiral and sine wave motion offer better results, but are not able entirely to get rid of unwanted shadows. However, they have disadvantages in the complexity of the mechanism and in the expense of the equipment. It is usually cumbersome and not readily adapted for other radiographic purposes. In addition, the Potter Buckey diaphragm absorbs part of the primary beam when the tube is "off centre". Notwithstanding these difficulties I have seen the method of Ziedses des Plantes used successfully in several centres on the continent and at/

at one in the United States. (In the latter it is Kieffer's method! ) I have not seen it in Great Britain or in Sweden.

Undoubtedly the most popular method in most countries is the Laminagraph with linear movement of the tube and film. As it is relatively cheap and can be quickly fitted to most radiographic installations, it does not distract from the versatility which we have, unfortunately I believe, come to demand of our equipment. The results are fairly satisfactory on the whole, but amongst clinicians and radiologists there is insufficient appreciation of the scope of the method and of its hazards and limitations.

The Grossmann- Chaoul Tomograph is used mostly in Germany and in Switzerland. I have seen only one in this country. While it offers no theoretical superiority over the type of tube movement which is parallel to the film, its rigid construction and mechanical efficiency reduce the "lost motion" and produce sharper radiographs. The great disadvantage of the Tomograph is its expense and lack of adaptability for other purposes.

PRESENT POSITION OF BODY SECTION RADIOGRAPHY.

Although Body Section Radiography is not so widely used in this country as in France or Italy, most hospital radiographic departments have their "Tomographic Attachments". In some, these are permanently attached to the Buckey couch, while in others they may be used at long intervals. As previously stated, the infrequent use of this method in some of the larger hospitals is due to lack of appreciation of its capabilities. In others, where the x-ray departments are working at full pressure, there may be little time for what some consider to be a time-consuming luxury. It must be borne in mind that the procedure may require four or five films and that the cost of these, combined with the occupation of an x-ray room for perhaps half an hour may be such that in times when economy is necessary the head of the department may feel that he could use these resources to better advantage. Again, the method has got into disrepute in some centres, sometimes by indiscriminate requests for the examination on the part of the physician or surgeon, and the supplying of a "set of tomographs" of indifferent quality by the x-ray department./

department. Indeed, poor radiographic technique and bad selection of cases has led more than one radiologist and clinician to say that he has "never seen anything on a tomograph that he has not been able to see on a plain x-ray." This may be the case for the embittered few, but for those who have seen the examination carefully carried out in suitable cases there can be little doubt of its great material help. During the past eight years, working principally at The Royal Cancer Hospital and at ~~the~~ Brompton Hospital, I have seen a very large number of cases where the presence of a lesion could not be demonstrated with certainty, to an experienced observer in plain, "bucky", stereoscopic or on films taken with special projections or on fluoroscopy, which were clearly visible on the tomograph. I have also seen cases such as upper lobe tuberculosis, where the patient was subjected to thoracotomy with a view to lobectomy, when the surgeon found a cavity in the apical segment of the lower lobe. This would have been visible on a tomograph, and would have contraindicated the operation. Having committed oneself to carrying out this procedure to a fairly extensive scale it must be done under the best possible conditions. One means to help to ensure is to insist that the request form is fully/



fully filled up and signed by a consultant. One usually finds that ones senior colleagues on a hospital staff appreciate the indications of tomography. Also in discussion of the cases the radiologist may point out that all the useful information has already been obtained. They more readily agree with him than registrars who may come to regard the x-ray department as uncooperative.

It goes without saying that the smallest film should be used which is necessary to cover the area of the body in question. In certain areas, such as the larynx, we take four "cuts" on a 12 x 10 film. In chest cases it is frequently possible to take two "cuts" on this size of film. Where single large films are used, it is usually our practice to take one radiograph at the suspected level and inspect it when developed before going on to take others, when the necessary information is given by the first.

Indications for Body Section Radiography.

CHEST.

Although the method was first used in the skull, it is in the thorax that it has achieved its widest popularity and scope.

Tuberculosis.

Although tuberculosis infiltration can often be/



be shown more clearly in tomographs than in plain radiographs, it is in the detection of pulmonary cavitation that its greatest value lies.

A great radiologist once said: "There are three types of cavities, the ones which you can see in the plain film, the ones you suspect but cannot be sure are present, and the ones you never dreamt were there until you saw the tomograph". Admittedly the latter are in the minority, but together with those in the second category, an average of 7 or 8 examinations is carried out daily at the Brompton Hospital. There are certain cases where, I believe, tomography should be carried out as a routine. Firstly in patients for thoracoplasty. It is a great help to the thoracic surgeon to know the extent, number and position of cavitation in the affected lung. Not infrequently lateral tomographs are an additional help when one wishes to determine the exact site of a cavity. When there is any disease in the contralateral lung, tomographs should always include that side. As previously stated the number of entirely unsuspected cavities is relatively small, but those I have seen leads me to the conclusion that in major and irreversible thoracic operations for tuberculosis, such as thoracoplasty, lobectomy or pneumonectomy/

The extent of benign and malignant growths

pneumonectomy the fullest information must be obtained regarding the extent of the disease. Upon finding unsuspected cavitation in the other lung may entail postponing the operation, abandoning it, or certainly some modification in the management of the case.

It is not an infrequent finding after thoracoplasty that the patient's sputum remains positive for tubercle bacille, or it may again become positive following conversion. In these cases there may be some disease, but no cavitation in the unoperated side. It is obviously important to exclude cavitation in the collapsed lung, and plain and "bucky" radiographs seldom give the necessary information. Admittedly, tomographs in this region are difficult to interpret, especially when the ribs have been regenerated, but they are frequently of assistance.

The above remarks also apply, but to a lesser extent in the selection of patients for artificial pneumothorax and pneumoperitoneum. These procedures are reversible and do not place the same strain upon the opposite lung.

Hilar adenopathy in primary tuberculosis, sarcoidosis, Hodgkin's disease, and other diseases, is sometimes difficult to identify in the plain radiograph, but may be clearly seen in tomographs.

The extent of benign and malignant growths  
of/

of the lung is almost always more clearly demonstrated by tomography. The surgeon and radiotherapist require information regarding which part of the lung is consolidated and which is collapsed - often a difficult matter for the radiologist. Other information is the extent and site of the bronchial stenosis or occlusion, the presence or absence of enlarged glands. Most of these cases, of course, are inoperable, but the radiotherapist finds the information given by tomography of considerable help in determining his beam direction and size of fields.

Again, following radiotherapy, tomography is useful in assessing the response of the lesion.

As in tuberculosis, cavitation may be demonstrated in cases of breaking down neoplasms, or in suppuration within a collapsed lobe.

In cases of retrosternal extension of the thyroid gland, I have seen cases where it was impossible to detect the growth in the posterior - anterior or special lateral views, but where lateral tomography clearly showed the lesion.

We have also in certain cases found tomography of help in localising lung abscesses, small areas of atelectasis, and in the recognition of arterio-venous aneurysm. In conclusion, it should/

should be recorded, that at the weekly clinical meetings at the Brompton Hospital, where cases of special interest are shown, or those presenting difficulty in diagnosis, the majority of these have had tomographic examination carried out.

#### HEAD AND NECK.

It has been my good fortune to examine radiologically, each year, about fifty new cases of carcinoma of the larynx. It is our routine in these cases to take two soft tissue lateral views, one taken during normal respiration and the other during phonation. These give considerable help to the laryngologist, and radiotherapist but their value is greatly supplemented by the antero-posterior tomographs which we employ routinely. In few, if any, parts of the body is it possible to demonstrate the anatomy and pathology so spectacularly by tomography in comparison with the detail seen in plain radiography, as in the laryngeal region. This was particularly impressed upon me in 1947, during a visit to the radiological clinics in Sweden. The Caroline Hospital in Stockholm has the best designed and equipped x-ray department I have seen, and the quality of its work is, on the whole, superlative. Yet in the examination of/



of the larynx they take great trouble to try to demonstrate the lesion in plain posterior - anterior radiographs. The information obtained by this method was scanty in the extreme, as compared with what might have been obtained by tomography. The reason why this was not carried out, was not because it was time consuming or on grounds of economy - indeed in most examinations, no amount of time, trouble or expense appeared to be too great to give the fullest possible information to the clinicians - it was on account of a prejudice against this method of examination by the head of the department, and I was informed that their tomograph attachment had not been used for three years.

It is true that the laryngologist is often able to get most of the information he requires by indirect laryngoscopy, but even in these cases, the additional evidence provided by radiography and particularly tomography is a permanent record of the condition. Also, the radiographs give a record of the response of the disease to treatment. In cases with a pathological or overhanging epiglottis or a tumour of the posterior pharyngeal wall it may be impossible to obtain a satisfactory view of the larynx. Lateral radiographs and tomographs often provide the necessary/



necessary information in these cases.

It is sometimes difficult to decide by indirect laryngoscopy the site of origin of an intrinsic laryngeal tumour. Tomography may help to determine this, and, as in the case of those tumours arising from the laryngeal ventricle, the accuracy of such information will influence the management of the case.

Subglottic extension of a tumour of the vocal cord may often be recognised in the lateral radiograph, when it is fairly large, but tomographs have demonstrated smaller lesions which were not visible in the lateral views or by laryngoscopy.

The extent of nasopharyngeal tumours is notoriously difficult to evaluate clinically, and even in lateral radiographs. We find lateral tomography quite helpful to define the tumours in this region and also in some cases to determine the presence of bony destruction.

Tomography gives evidence of bony destruction by neoplasms of the paranasal sinuses, particularly the antra and thus supplementing the information obtained from the routine views. The same also applies to bony destruction from rodent ulcers.

Some people employ tomography in the examination/

examination of the tempero-mandibular joint, and in the petrous portion of the temporal bone. So far I have not used it in these sites except in normal cases for demonstration purposes.

OTHER SITES.

The above, represents the bulk of my experience, but it has been applied extensively by other workers in the vertebral column in the detection of metastases, fractures, dislocations and tuberculous infections. In the abdomen, it has been used to detect calcification in aneurysms of the aorta and more recently in excretion urography.

## HORIZONTAL BODY SECTION RADIOGRAPHY.

The purpose of this method is to obtain radiographs of planes at right angles to those obtained by the more usual form of body section radiography. At first it might be thought that the obvious method of approach was to stand the patient upright on the couch, and proceed as for vertical sections. Fig. 13.

Part 2.

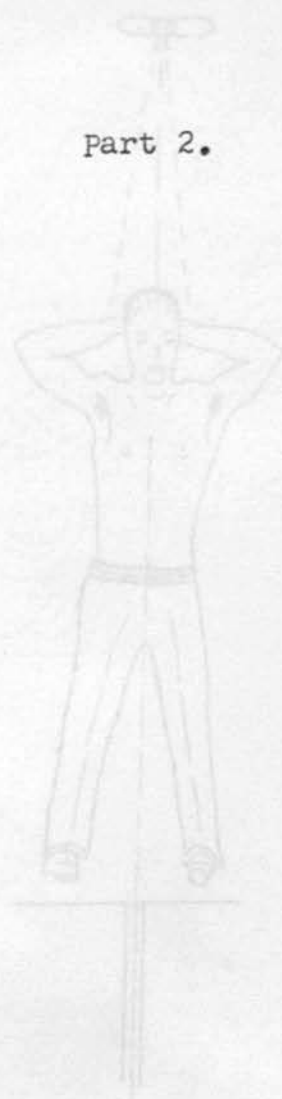


Fig. 13.

## HORIZONTAL BODY SECTION RADIOGRAPHY.

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The purpose of this method is to obtain radiographs of planes at right angles to those obtained by the more usual form of body section radiography. At first it might be thought that the obvious method of approach was to stand the patient upright on the couch, and proceed as for vertical sections. Fig. 15.

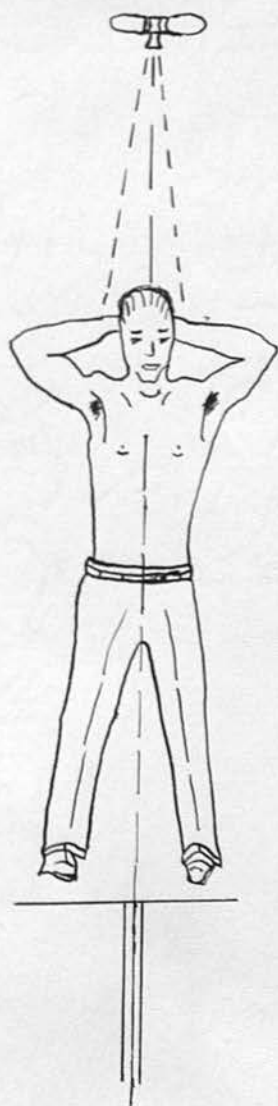


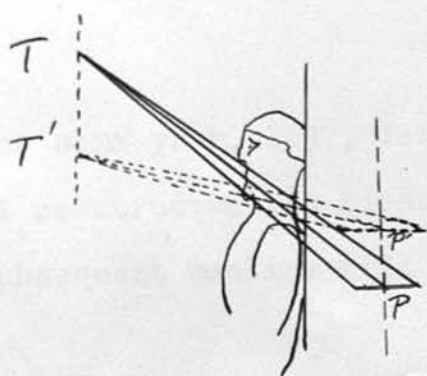
Fig. 15.

However, it is obvious that the large object film distance combined with the amount of body tissue the x-ray beam has to traverse renders the method impracticable except in certain parts of the body.

KIEFFER.

The first suggestion of a different method for approach was made by Kieffer<sup>13</sup> at the 5th International Congress of Radiology at Chicago in September 1937, and in a paper the following year he described two theoretical techniques.

The first (Fig. 16) shows the tube connected by means of a lever to the horizontal cassette holder. The lever is pivoted at a point at the level of the section which it is desired to demonstrate. During the exposure, the tube depressed vertically and at the same time the cassette rises, also vertically, and remains in a horizontal position. Since the magnification of the image remains constant, and the plane of the section is parallel to the cassette a true horizontal image of the section will be reproduced on the film.

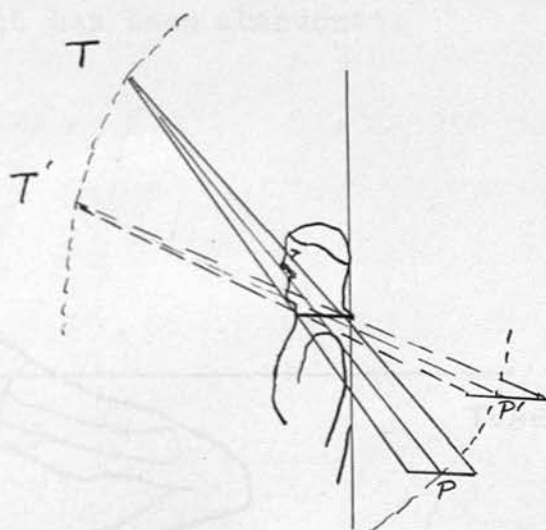


After Kieffer.  
First Method.

Fig. 16.



His second system was more simple mechanically, (Fig. 17). In it, the tube and cassette described an arc of a circle during the exposure, again with the cassette remaining horizontal. This method also would render a cross section on the film at the level of the pivot, but neither this nor Kieffer's first method was ever put into practice.



After Kieffer.

Second Method.

Fig. 17.

#### WATSON.

In the same year, 1937, Watson<sup>23</sup> took out a patent and constructed his first apparatus. This, and his subsequent machine will be described later.

#### DE ABREU.

In 1944 De Abreu<sup>7</sup> described a method of obtaining/

obtaining horizontal sections of the thorax, (Fig. 18). In this, the patient was placed in an exaggerated lordotic position and the body sections were taken with an orthodox type of apparatus. The only result which he shows gives poor detail and only demonstrates the anterior part of the thorax. He has not described this method in any subsequent publication and I conclude that it has been abandoned.

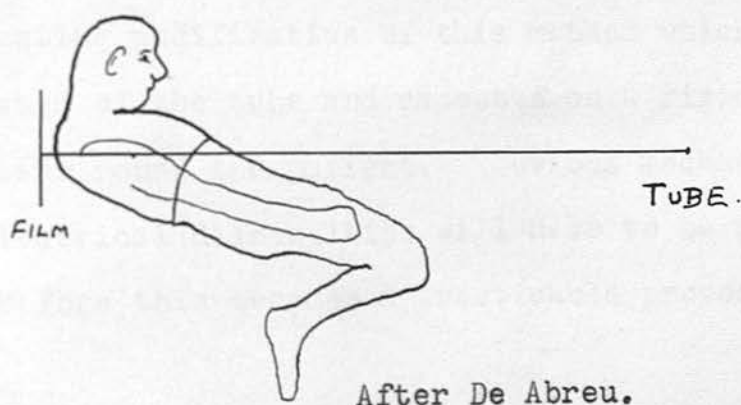


Fig. 18.

FRAIN AND LACROIX.

In 1947, Frain and Lacroix<sup>8</sup> described what they/

they thought was an original theoretical method of obtaining horizontal body sections. This consisted of a turntable on which the patient stood, connected to a platform on which the cassette rested in a horizontal position. They made no references to Watson's publications, and in a personal communication informed me that they were not aware of them. Their apparatus, which was rather crude appeared at the Seventh Congress of French Speaking Radiologists in Paris in 1949. It had not so far been used on a living patient.

However, in a cine-film, they showed an interesting modification of this method which consisted of the tube and cassette on a rigid rod, rotating round the patient. Obvious mechanical and electrical difficulties will have to be overcome before this becomes a practicable proposition.

VALLEBONA.

Just after Fraim and Iacroy's first publication on this subject Vallebona<sup>21</sup> described his method and showed his results. His principles were identical with those of Watson and his first apparatus bore a very close resemblance to Watson's prototype. In a personal communication he informed me that he knew nothing of Watson's publication or apparatus at that time. During the next three years he and his staff have devoted a great amount of time to perfecting his apparatus/

apparatus and employing it for the examination of patients. They have written a number of articles and have read papers on the subject in Italy, France and Switzerland. As a result of their efforts there has been considerable enthusiasm for "this Italian method of Radiography" on the Continent. In a paper read in Paris in 1939<sup>18</sup> I was able to correct some of their misapprehensions!

Vallebona's latest apparatus (Fig. 19) differs in no major respect from that of Watson. Having had a lot of money spent on its development, it is rather more easy to operate and is more streamlined.



Fig. 19.  
Vallebona's  
apparatus.

One noteworthy feature is the incorporation of a collineator, by means of which the tube can quickly be aligned with the apparatus. This is more convenient, if slightly less accurate than my own method which I will describe later.

#### GEBAUER.

In 1939 Gebauer<sup>10</sup> published an article describing a method of obtaining horizontal body sections identical with ours and Vallebona's. The apparatus which he described was similar to Watson's prototype, although motor driven. An improved version has recently been constructed by the firm of Siemens.

#### DESCRIPTION OF OUR APPARATUS.

Watson built his first apparatus in 1937, (Fig. 20.) which consists of a turntable on which the patient stands. This is connected by a 1 : 1 gear to a small platform on which the cassette rests. The x-ray tube points obliquely downwards with its central ray directed through the patient to the centre of the horizontal cassette. During the time of the exposure the patient is rotated through 360°. By means of the coupling, the cassette rotates in the same direction and at the same speed.



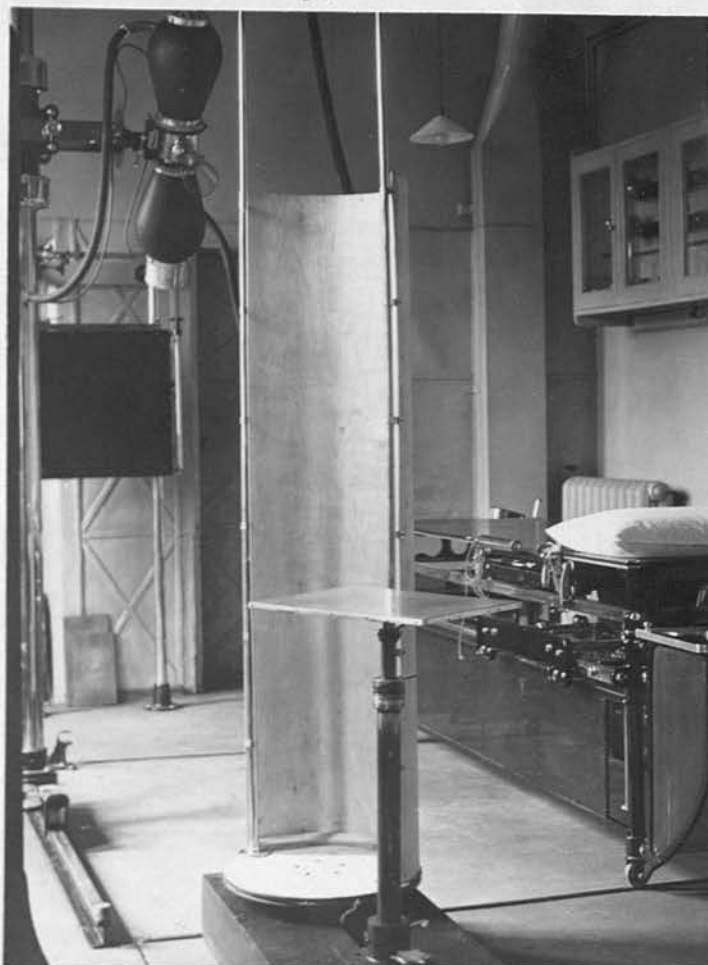


Fig.20.  
Watson's First Apparatus.

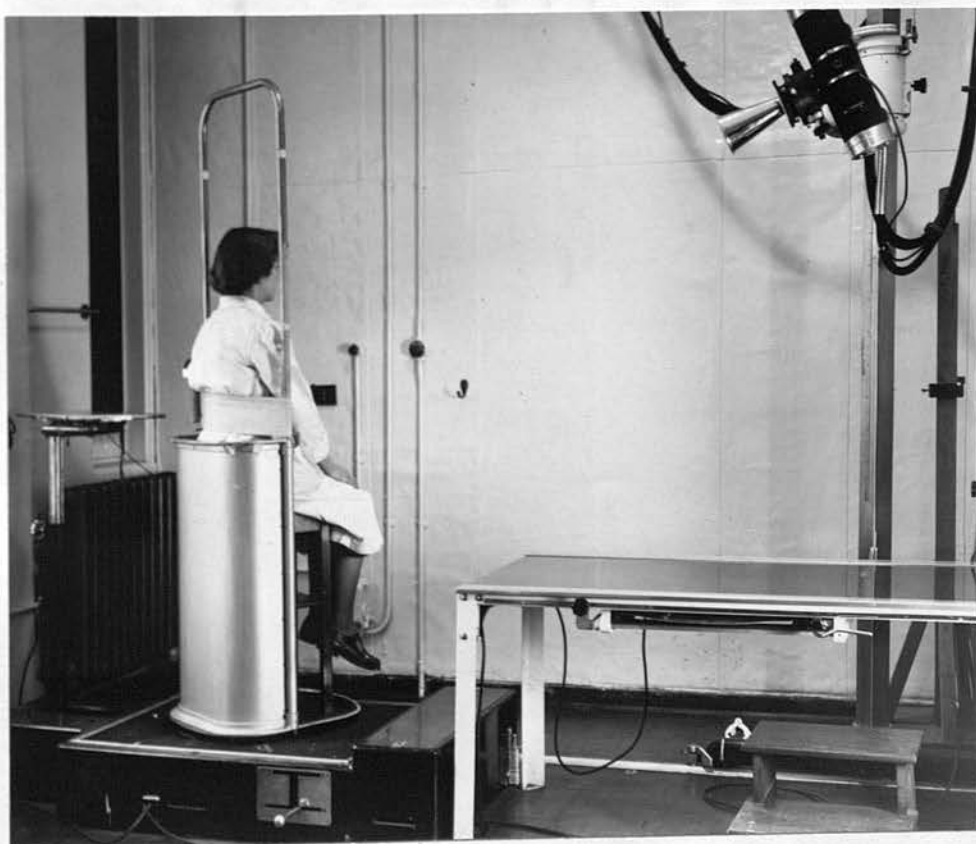


Fig.22.  
Watson's Second Apparatus.

His second apparatus (Fig. 21.) was constructed by the Medical Supply Association, Ltd. in 1939. In this the turntable was driven by an electric motor through a four speed gear box. Adjustments were provided to raise and lower the patient and the cassette independently. The patient-film distance, which was kept to the minimum, could be varied according to the size of the cassette used. (Fig.22).

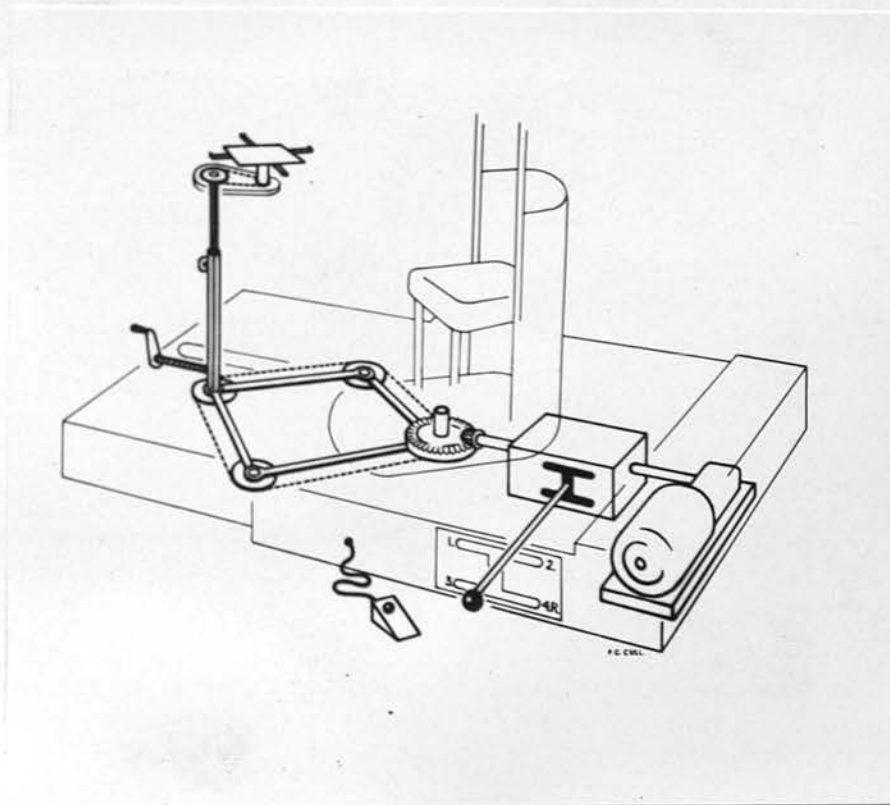


Fig.22.

Sectional Drawing of the Apparatus.

Fig. 23 shows in diagrammatic form the patient sitting on a stool on the turntable. The central ray FO' passes through his axis of rotation at O to the centre of the film at O'. A and B are points on a horizontal plane through O. The shadows cast by these points with the patient stationary would fall on the film at A' and B' respectively. If the patient and film are now rotated through  $180^{\circ}$  (Fig. 24) the shadow of O at O' will, of course, occupy exactly the same position on the film as in Fig. 23, because they represent the respective axes of rotation.

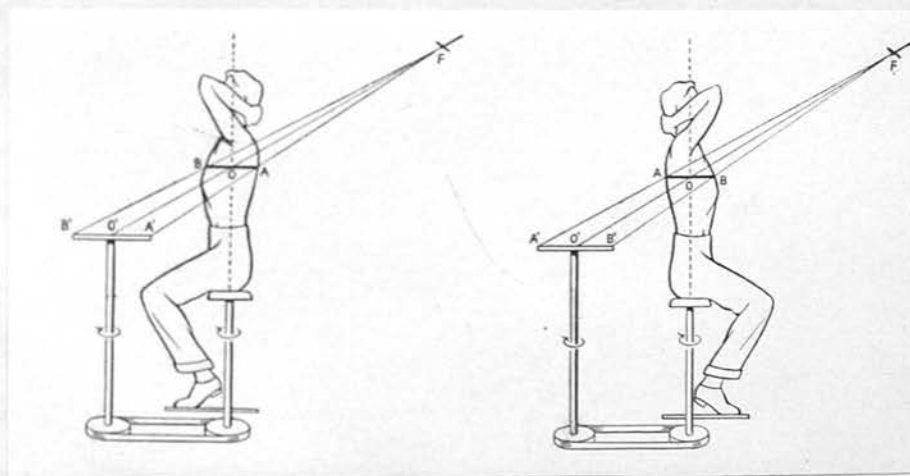


Fig.23.

Fig.24.

Fig.23.

Diagram showing the patient seated on the turntable.

Fig. 24.

Similar to previous after rotation through  $180^{\circ}$ .

A is now distal to the tube, but its shadow A' is still cast on the same point on the film, because the latter has turned through  $180^{\circ}$ , and BOA is parallel to B'O'A'. It can similarly be shown that the shadows of all points on the plane AOB in Fig. 23 occupy precisely the same positions on the film in Fig. 24 after half a revolution, and also for all angles of rotation. Thus, if an exposure were made while the patient was being rotated through  $360^{\circ}$ , a sharp image of every point on the plane AOB would be reproduced on the film. Shadows of objects above and below the selected plane are blurred and diffused over the film, as in conventional body section radiography. To demonstrate this, Fig. 25 shows a point X situated above the plane AOB on the line FO. With the patient stationary, the shadows cast by X and O coincide at O'X'. Following rotation through  $180^{\circ}$  (Fig. 26) it can be seen that X' and O' are now separate. If the exposure were made during rotation through  $360^{\circ}$ , X' would not remain on one point of the film, but would move about in a circle centred mid-way between X' and O' in Fig. 26. Depending upon the distance of X from the plane AB, and its degree of opacity to x-rays, X' will appear as a blurred shadow on the film, or may not be visible at all.

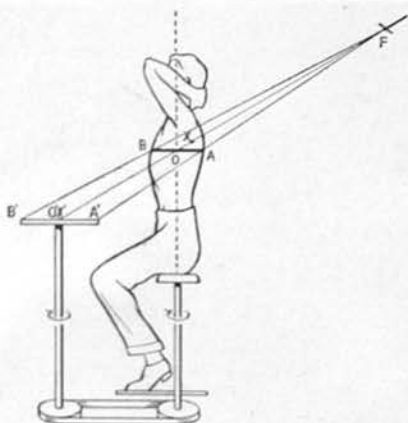


Fig. 25.

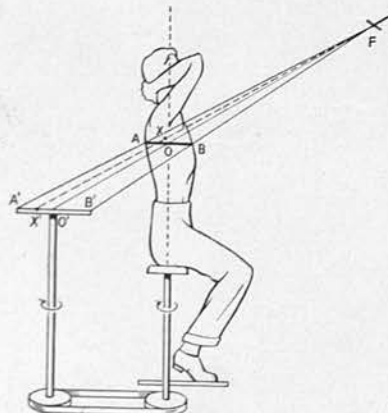


Fig. 26.

Showing how the images of objects above and below the desired level are blurred on the film.

In practice, of course, the sharp shadows on the film are cast by a thin section of the body and not by a plane, which has no depth. The thickness of this section depends upon the following:

1. The opacity of the tissues at or about the desired level.
2. The angle of inclination of the tube, i.e. the angle  $FO'B'$  in Fig. 26.

Fig. 27 is a photograph of a cylinder 6 cm. in diameter round which has been wound lead wire at two/



two turns per cm. Fig. 28 is a radiograph of the cylinder set up as for a horizontal section, but with the object and film stationary.

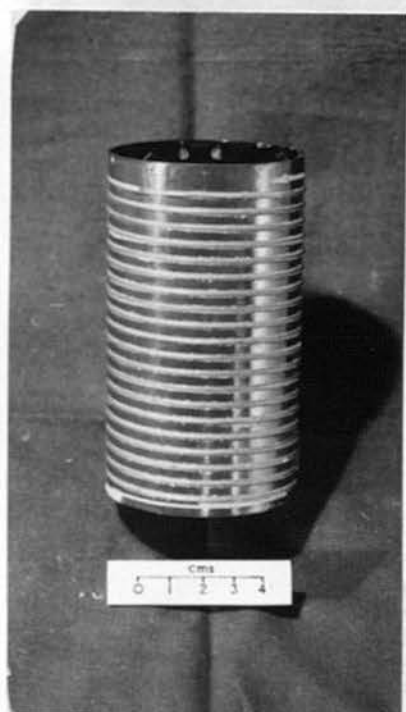


Fig. 27.

Plastic cylinder  
wound with a coil  
of lead wire.



Fig. 28.

Radiograph of Fig. 27  
set up in place of the  
patient as in Fig. 23.

Fig. 29 is a horizontal section of the cylinder, taken with the normal rotation through  $360^\circ$  and with the x-ray beam at  $25^\circ$  to the horizontal. It will be seen that the wire is in /

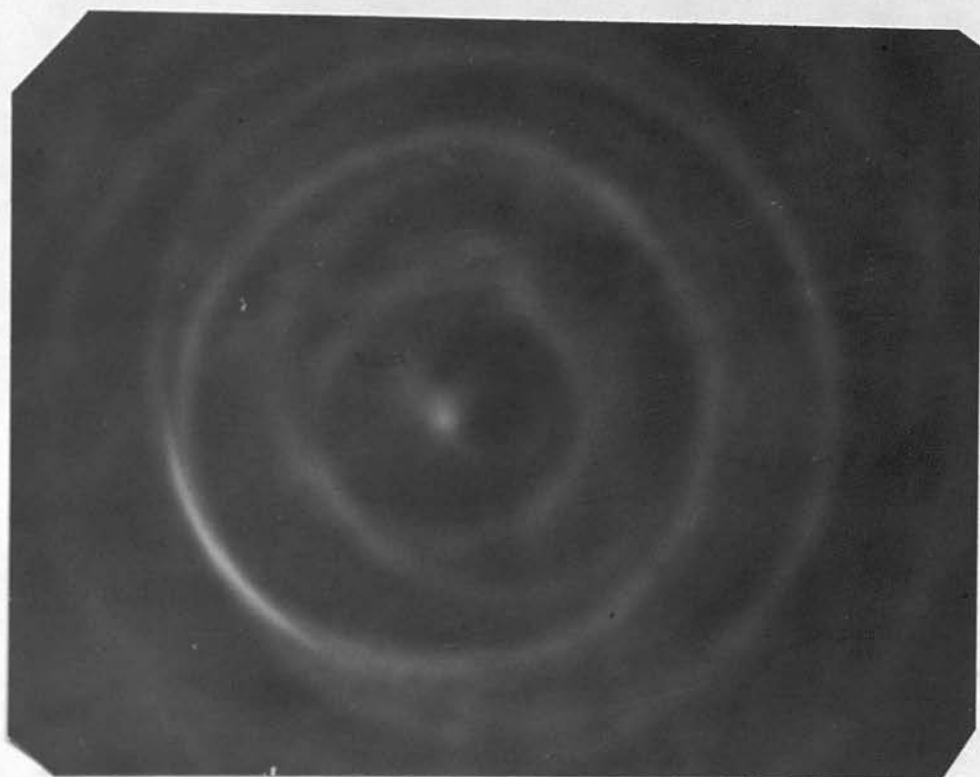


Fig. 29.

Horizontal Section of Fig. 27 with the tube at  $25^{\circ}$ .

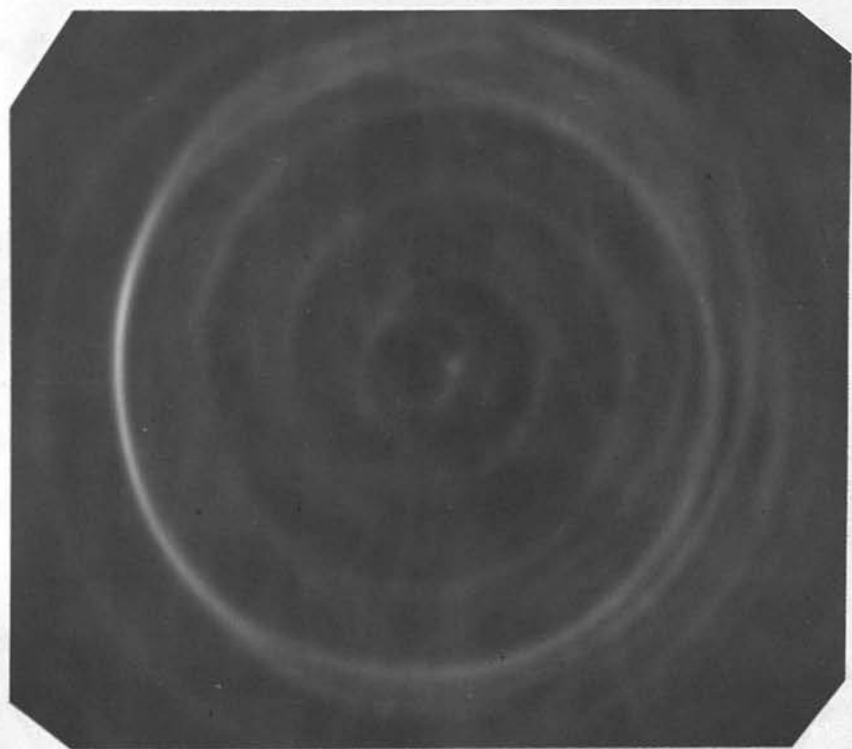


Fig. 30.

Horizontal Section of Fig. 27 with the tube at  $35^{\circ}$ .

"in focus" for one sixth of a turn, giving the depth of the section as 0.8mm, neglecting the thickness of the wire. Fig. 30 is a horizontal section of the same cylinder with the beam at an angle of  $35^{\circ}$ . The thickness of the section is in this case 1.5mm, thus demonstrating without complicated mathematics, that the greater the downward inclination of the tube, the thicker will be the section. Contrast increases similarly, and we find in practice that the optimum angle lies between  $25^{\circ}$  and  $35^{\circ}$ .

#### DETAILS OF TECHNIQUE.

With the rotating anode tube at about  $30^{\circ}$  a focal-film distance of 3 metres is employed. The object-film distance is generally 0.6 metre, giving a magnified image on the film of 1.25:1.

The correct alignment of the focal spot with the axes of rotation of the object and film is of vital importance in order to secure sharp images.

To demonstrate this, Fig. 31 is a plan of the layout. As has been shown, a point at the axis of rotation of the object, or, indeed, any point on the same horizontal plane, casts a sharp shadow on to the film during rotation through  $360^{\circ}$ . On displacing the tube to  $F_2$  (Fig. 32) and making a short exposure with the apparatus stationary the shadow of O is cast on to the film at  $O''$ . If the/

the film and object are now turned through  $90^\circ$  and another exposure made, Fig.33, there will now be another shadow on the film at  $O'''$ . If the exposure had been made during the rotation through  $90^\circ$  a quadrant of a circle would have appeared on the film, or if the rotation had been through  $360^\circ$  a complete circle would have resulted.

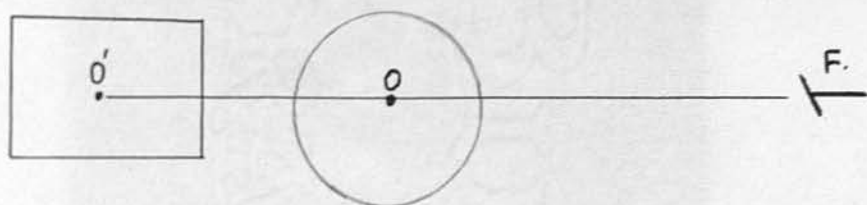


Fig.31.

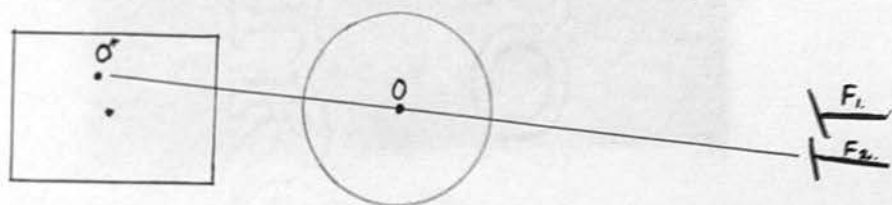


Fig.32.

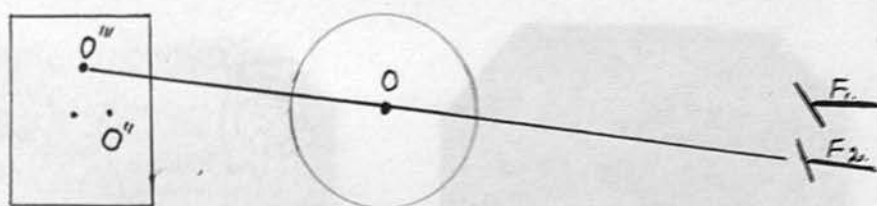


Fig.33.

In employing these principles to align the apparatus, a wire is held vertically by a clamp, Fig.34, on the turntable and an exposure is made during/

during a complete revolution. If the resulting image on the film is a circle, (Fig. 35) the tube is moved a little to one side and further exposures made, until, by trial and error, a sharp image of the cross section of the wire is obtained (Fig. 36). H

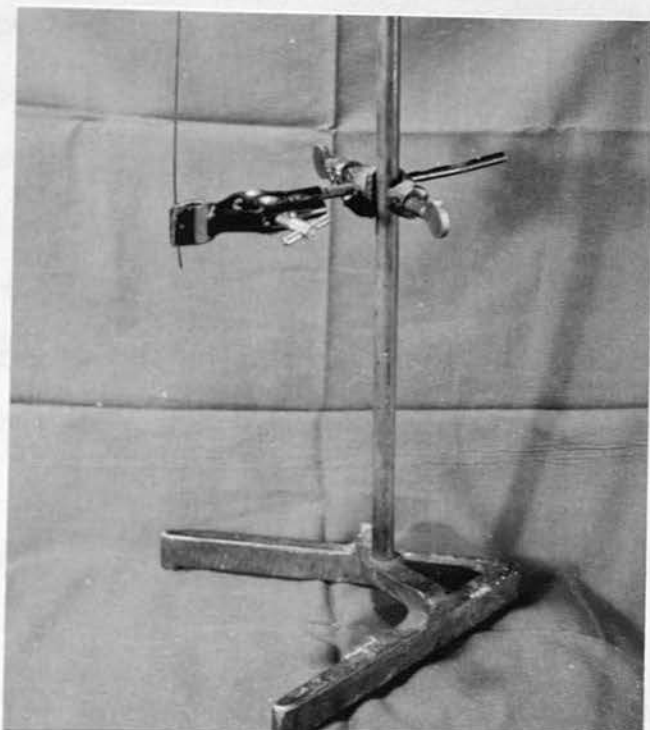


Fig. 34.

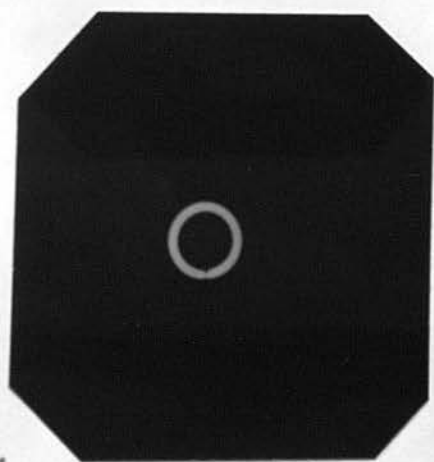


Fig 35.

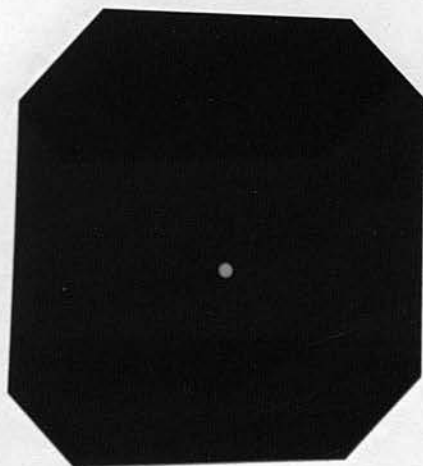


Fig.36.



Having once determined the correct position for the tube it may be left there until, at a later date, results show that the images are not as sharp as they should be. The positioning of the tube vertically is not nearly so critical, but it is obviously desirable that the beam should just cover the film, using a slit diaphragm. This alignment may be done by fluoroscopy, by placing an intensifying screen on the cassette holder and a cross wire in the centre of the diaphragm. The tube height is then adjusted until the image of the cross wire is in the centre of the fluorescent screen. By having an intensifying screen suspended above the turntable the point of intersection of the central ray and its axis of rotation is noted. This height is the level at which the horizontal sections of the patient will be taken.

In taking horizontal sections of the chest, the patient sits on an adjustable stool which is raised or lowered until the selected level on his body is at the height mentioned above. An immobilising band is then placed round him and tightened. The fastest available film is used with normal intensifying screens, and the cassette, 17 x 14 inch or 15 x 12 inch (43 x 35.5cm. or 38 x 30.5cm.), is placed in its holder. A gear is engaged, usually top, which/

which gives a complete revolution in 3 seconds, and the patient is told to stop breathing. He is then rotated, and when steady, after, say, half a revolution, an exposure of 3 seconds is made and the motor stopped. Other exposure factors are 75-90kv and 100-150ma. After two heavy exposures, study of the tube rating chart, and perhaps more urgently, a glance at the colour of the anode of the tube advises one not to continue for several minutes! In order to get cuts at other levels the patient's seat may be raised or lowered as desired.

#### USES AND ADVANTAGES OF THIS METHOD.

I have employed horizontal body sections in the normal and in a variety of intrathoracic abnormalities. The following structures and features are demonstrated:

##### Trachea and Bronchi.

The entire length of the trachea is clearly shown together with its relationship to the other mediastinal structures. Deviation from its normal course and distortion of its lumen by external pressure can be appreciated (Fig. 70 ). If the cut is taken at the level of the bifurcation, the carina and right and left main bronchi are visible (Fig. 44 ). Bronchial occlusion by a neoplasm is shown in Fig.

##### Aorta/

### Aorta.

This is demonstrable throughout its course in the chest with the exception of the root which merges with the heart shadow. Its diameter can be measured at any point. The portions shown, are part of the ascending portion (Fig. 43), the horizontal portion of the arch with its relations to the trachea and oesophagus (Fig. 41), and the descending part. We have not been able to demonstrate the narrowed portion in a case of coarctation of the aorta, but in a patient with this abnormality (Case 5, Figs. 66 & 67) the following features are shown:

- (a) Dilated ascending portion.
- (b) Dilatation below the coarctation.
- (c) Normal descending aorta below this.

A case of aneurysm is illustrated in Fig. 50.

Fig. 53 shows a case of right sided aortic arch with the descending aorta also on the right without dextrocardia. A double aortic arch is a rare abnormality, described in Case 4, which cannot be so convincingly demonstrated by any other method in the living patient. The right and left branches of the aorta, although lying at slightly different levels, (Figs. 59 & 61) are shown encircling the trachea in a vascular ring in Fig. 60.

### Oesophagus.



### Oesophagus.

After the patient has swallowed a thin tube containing an opaque solution, the course and relationship of the oesophagus can be determined Fig. 61 . Swallowing barium is not so satisfactory except where obstruction is present. In a number of cases the air-filled oesophagus may be seen behind the trachea. (Fig. 38 ).

### Pulmonary Arteries.

The bifurcation of the pulmonary artery is shown in Fig. 44 . In the original films the smaller branches can be seen extending into the lung fields.

### Vertebrae.

The body, laminae, transverse and spinous process, and the neural canal are shown in films of sufficient penetration.

### Heart.

For the first time it is possible to obtain the true cross section of the heart. This may prove of value in assessing enlargement of certain of the chambers, and may prove of value in determining the cardiac volume.

### Possible use in Radiotherapy.

When a malignant intrathoracic lesion is demonstrated the cross section image of the thorax can be photographically reduced to life size on another film. It would appear that this would simplify/



simplify beam direction and calculation of the tumour dose.

Other intrathoracic lesions demonstrated in this thesis are:

Bronchogenic neoplasm with enlarged bronchopulmonary glands:

Retrosternal thyroid and the position of a lung cavity.

A new perspective of an azygos lobe is shown in Fig. 53.

#### ILLUSTRATIVE CASES.

##### Case 1. The Normal Subject.

Fig. 37 is a transverse section through the lower cervical spine and shows a cervical vertebra with the trachea anteriorly.

Fig. 38 taken above the sterno-clavicular joints shows the trachea with the accompanying blood vessels. Just behind and slightly to the left of the trachea is the air-filled oesophagus. The vertebra and lung apices are also shown. Fig. 39 is a diagram of the features shown.

Fig. 40 is taken at the level of the sterno-clavicular joints, which are demonstrated.

Fig. 41 and 42 show the horizontal portion of the aortic arch, which partially surrounds the trachea/



trachea. Fig.

Fig. 43 is taken just below this and shows both the ascending and descending portions of the aorta. The latter, it will be noted, lies anteriorly and slightly to the left of the vertebral body.

Fig. 44 and 45 show the carina with the left and right main bronchi. The left and right branches of the pulmonary artery are also visible in this cut.

Fig. 46 and 47 taken at lower level give views of the heart in cross section, as well as the sternum, aorta, vertebrae and ribs. Little detail is visible in the lungs on account of the heavy exposure necessary to define the denser thoracic structures. With less exposure, however, the smaller vascular markings are easily seen.

In order to show details of the vertebrae, on the other hand, the necessary increased penetration would be at the expense of less dense structures, such as the aorta and chest wall.

Fig. 48 taken at the level of the diaphragm shows the liver and the posterior sulci of the lungs. On the left, the stomach air bubble is visible.

## Case 2. Aneurysm of Descending Thoracic Aorta.

Fig. 49 is a P.A. view of a case of aneurysm of the descending aorta.

Fig/

Fig. 50 taken at the level of the bifurcation of the pulmonary artery gives a cross section of the lesion.

Case 3. Right sided Aortic Arch, with the Descending Aorta on the right.

Fig. 51 and 52 are P.A. views showing a right sided aortic knuckle.

Fig. 53 is a cross section taken at the level of the horizontal portion of the aortic arch. This shows the latter to be lying on the right side of the trachea. The fissure between the azygos lobe and the remainder of the upper lobe is clearly visible.

Fig. 54 taken at the level of the bifurcation of the trachea shows the descending aorta lying anteriorly and slightly to the right of the vertebral column.

Case 4. Double Aortic Arch.

The P.A. view, Fig. 55 shows an aortic knuckle of unusual shape. The barium filled oesophagus is displaced to the left, just above the knuckle, while the impression at the level of the latter is smaller than usual. The lateral and oblique views (Figs. 56 and 57) show the oesophagus to be displaced anteriorly by a fairly dense opacity which was found to pulsate on screening.

Fig/

Fig. 58 is a horizontal section taken at the level of the sterno-clavicular joints. The appearances here are within normal limits. The trachea is shown together with its adjacent vascular structure.

Fig. 59 is taken at the level of the first costochondral junction, (cf Fig. 55) and shows the right branch of the aortic arch lying to the right and behind the trachea. The shadow to the left of the trachea is probably the left common carotid artery.

Fig. 60 is taken about 0.5cm. further down, and shows the trachea compressed between the two branches of the aortic arch.

Fig. 61 taken 1cm. below this, is below the level of the right branch, and now only shows the left branch lying in the normal position of the aortic arch. Indeed, this radiograph would pass for normal. The round opacity behind and to the left of the trachea is due to an opaque tube in the oesophagus.

Fig. 62 shows the descending aorta, after union of the two branches, lying in its normal position, slightly to the left of the spine.

Fig. 63 is a drawing showing the probable anatomical arrangement, with the two branches of the

the aorta lying at different levels. These appear to be approximately the same diameter, an unusual finding in the cases reported in the literature.

Case 5. Coarctation of the Aorta.

The typical notching is shown in the P.A. view. (Fig. 64). Also visible is the "double aortic knuckle", produced by the shadows of the small knuckle and the enlarged left subclavian artery above it. The oblique view, (Fig. 65) shows forward displacement of the barium filled oesophagus below the arch of the aorta. This was confirmed by angiocardiology to be due to a dilated portion of the aorta, just below the coarctation.

Fig. 66 is a horizontal section taken at this level, and shows the oval, dilated aorta.

Fig. 67, taken at the level of the bifurcation of the trachea, shows that the descending aorta is now normal in size. The ascending portion, however, as one would expect, is of rather greater diameter than normal.

Case 6. Retrosternal Goitre.

The P.A. view of the chest (Fig. 68) shows a large opacity in the upper mediastinum with displacement of the trachea to the left.

Horizontal sections, taken at the level of the sterno-clavicular joints, (Fig. 69) and just above the aortic arch (Fig. 70) shows the anterior mediastinal/



mediastinal tumour and the displacement and narrowing of the trachea.

Case.7. Bronchogenic Carcinoma.

The peripheral pulmonary lesion with enlarged bronchopulmonary glands is shown in the plain film and vertical tomograph. (Figs. 71 and 72).

These lesions are again demonstrated in the horizontal section, taken at the level of the carina. (Fig. 73).

Case 8. Bronchogenic Carcinoma.

Fig. 74 is a vertical tomograph showing narrowing of the left upper lobe bronchus with collapse and bronchial dilation situated distal to the lesion.

Fig. 75 is a horizontal section at the level of the aortic arch and shows the segmental collapse of the lung with dilated bronchi.

Fig. 76 is taken at the level of the horizontal portion of the left main bronchus, into which the tumour projects. The collapsed portion of the upper lobe is situated anteriorly.

Case 9. Pulmonary Cavity.

Fig. 77 shows an artificial pneumothorax, with a cavity in the underlying lung. A horizontal section at the level of the bifurcation of the trachea, Fig. 78, shows the cavity together with the adjacent atelectatic lung tissue.

Opposite it, the carina is seen to be displaced to the right.



SUMMARY.

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2. Anderson, J.A. & Stuart, H.J. Roentgen. 1939, LXIX, 1-7.

While horizontal body section radiography introduces no new fundamental principle, it necessitates the use of very special equipment. The first model for this purpose was constructed in England in 1937 and was followed in 1939 by the improved version which I am now employing. It consists of a motor driven turntable, on which the patient sits, coupled to a rotating platform on which the cassette rests in a horizontal position. The x-ray tube, with a focal film distance of 3 metres, points obliquely downwards at the film. An exposure time of 3 seconds is used, during which time the patient and cassette are turned through 360°. The section, of a depth of 1mm. is on the horizontal plane at the point of intersection of the central beam and the patient's axis of rotation.

The method appears to be of value in the diagnosis of and localisation of intrathoracic lesions. Cases in which it was used include, double aortic arch, coarctation of the aorta, right sided aorta, aortic aneurysm, retrosternal goitre, carcinoma of the bronchus and pulmonary cavitation.

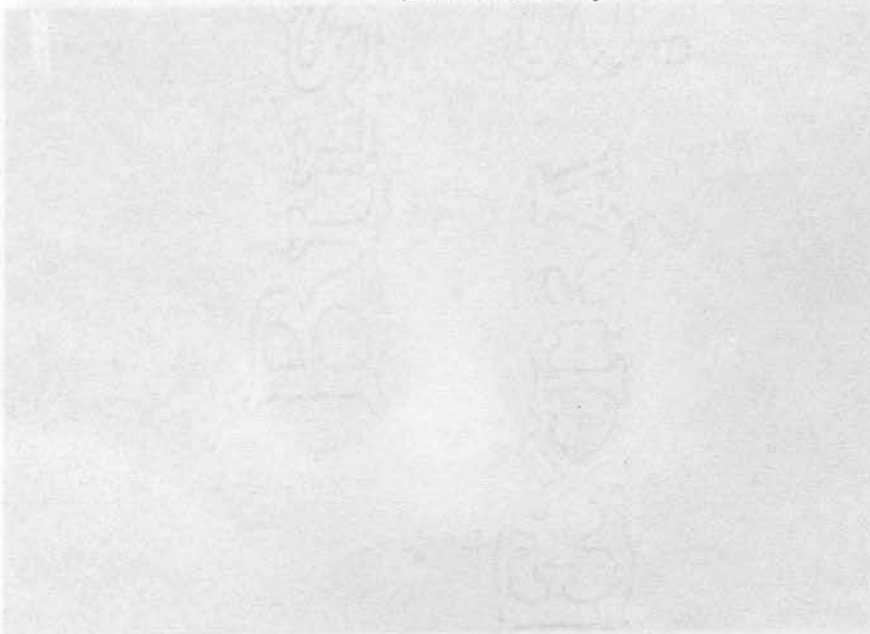


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29. Ziedses des Plantes, B.G. Acta Radiol. 1932, X111, 182.



I L L U S T R A T I V E

C A S E S .



Section taken above the ...

Case 1.

The Normal Subject.

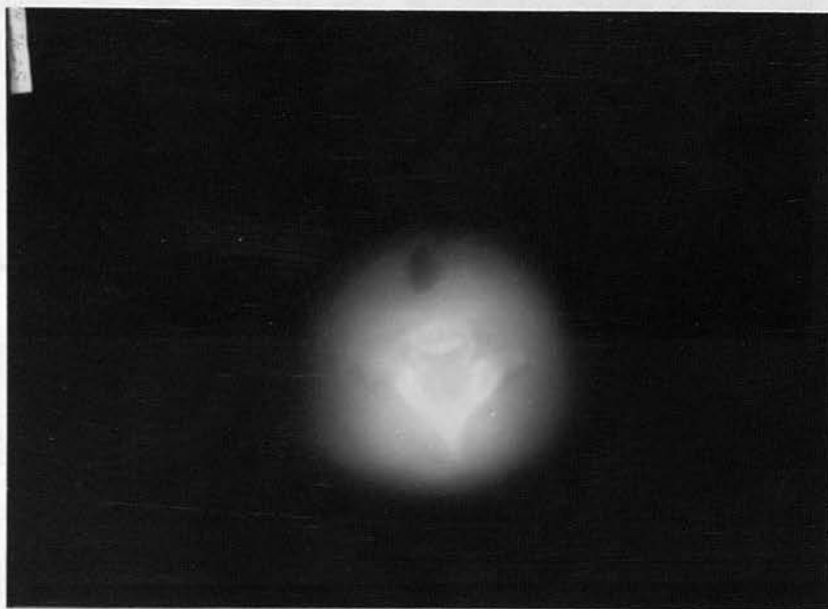


Fig.37.

Section taken through the Neck.



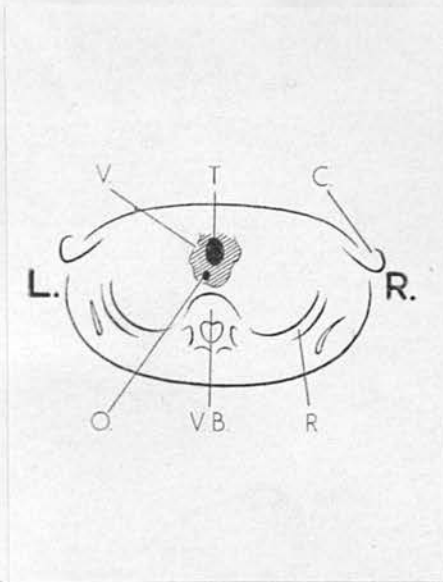
Fig. 38.

Section taken above the Sterno-Clavicular Joints.



Case 1.

The Normal Subject. (Continued)



- T. Trachea.
- C. Clavicle.
- R. Rib.
- V.B. Vertebral Body.
- O. Oesophagus.
- V. Blood Vessels.

Fig.39.

Diagram of the features shown in the previous Fig.



Fig.40.

Section at the level of the Sterno-Clavicular Joints.

The Normal Subject. (Continued)

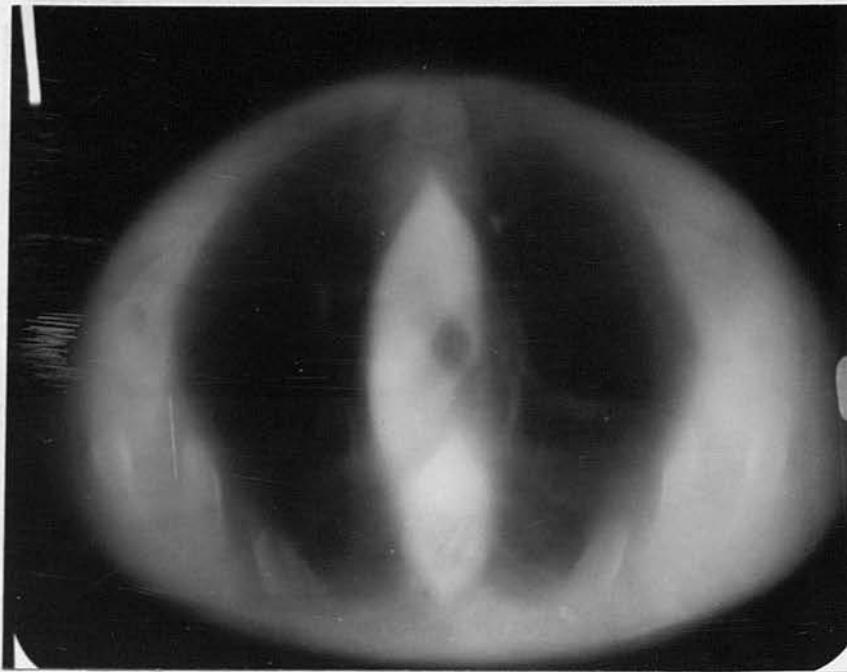


Fig.41.

Section taken at the level of the horizontal portion  
of the Aortic Arch.

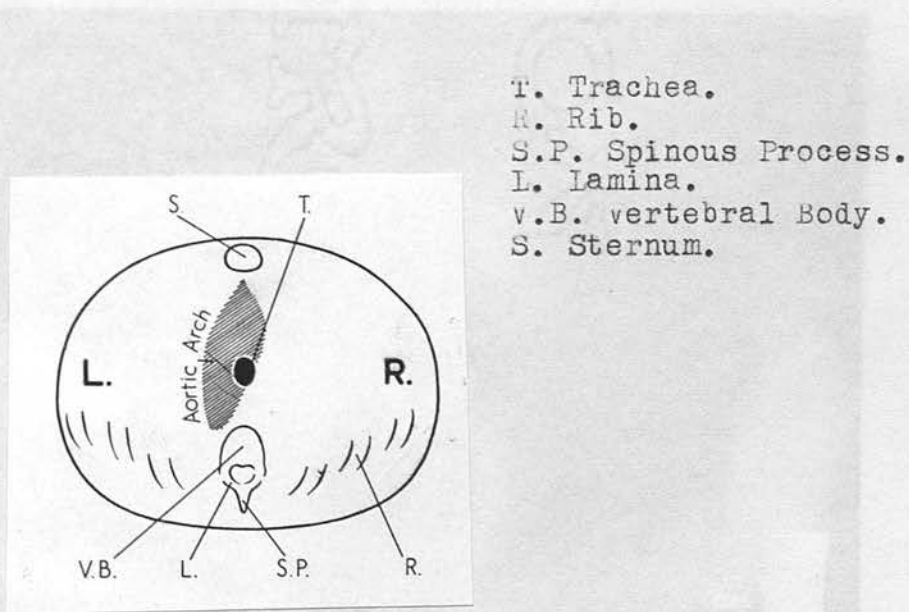


Fig.42.

Diagram of the features seen in the previous Fig.

Case 1.

The Normal Subject. (Continued)



Fig.43.

Section taken just below the horizontal portion of the aortic arch. Note ascending and descending aorta.

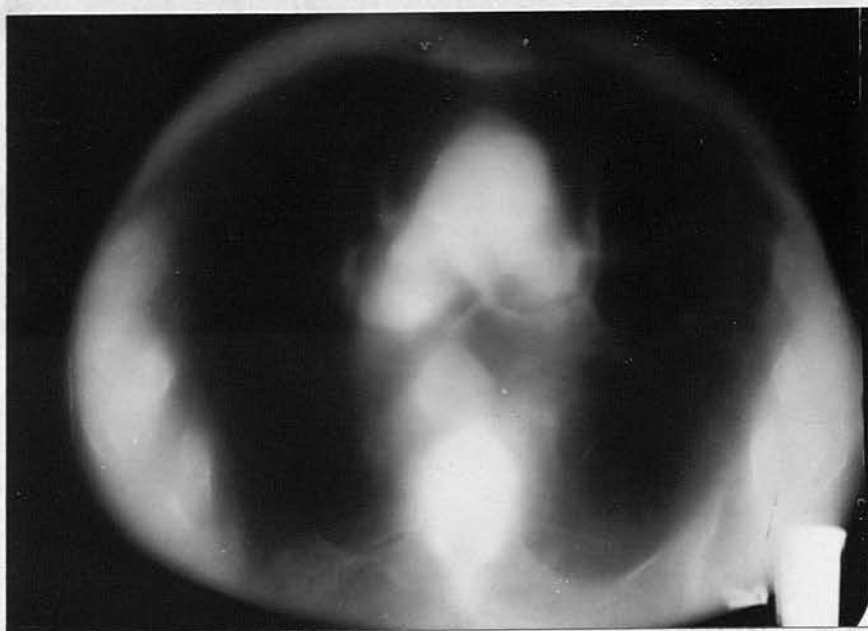
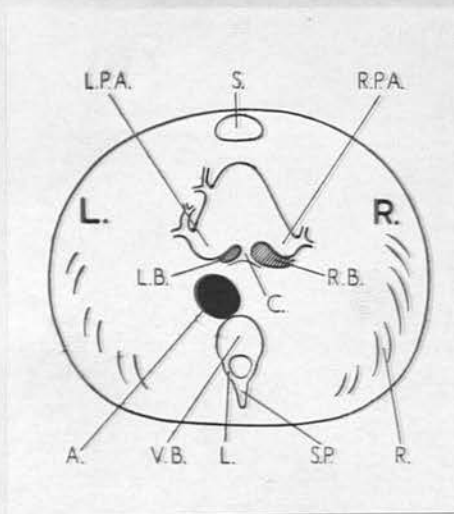


Fig.44.

Section taken at the level of the bifurcation of the Trachea.

The Normal Subject. (Continued)



R.P.A. right Pulmonary  
Artery.

L.P.A. Left " "

R. rib.

S.P. Spinous Process.

L. Lamina.

V.B. Vertebral Body.

A. Descending Aorta.

C. Carina.

R.B. Right Bronchus.

L.B. Left Bronchus.

Fig.45.

Diagram of the features seen in the previous Fig.

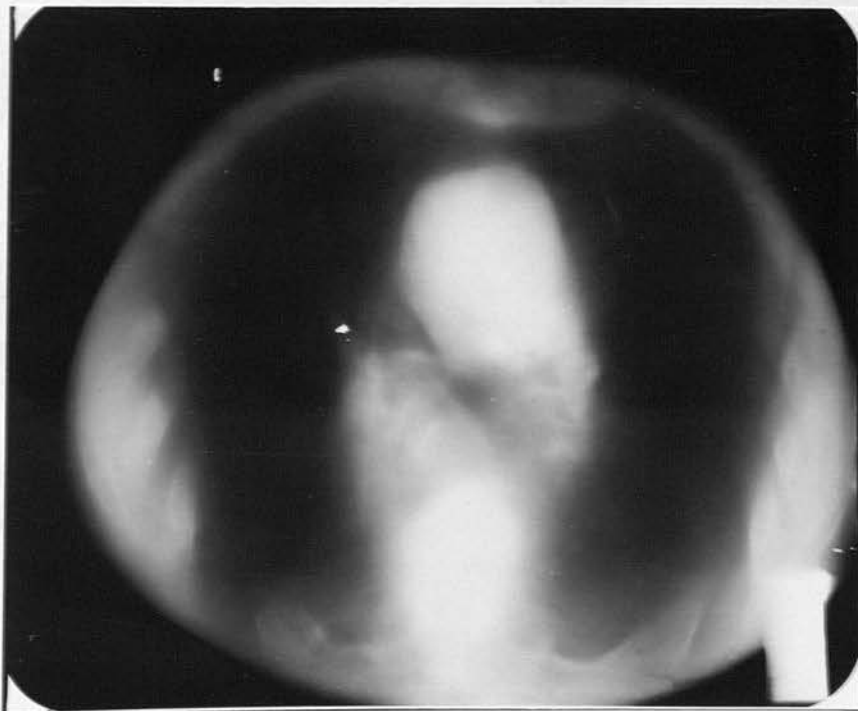


Fig.46.

Section taken through the cardiac shadow.

Case 1.

The Normal Subject. (Continued)

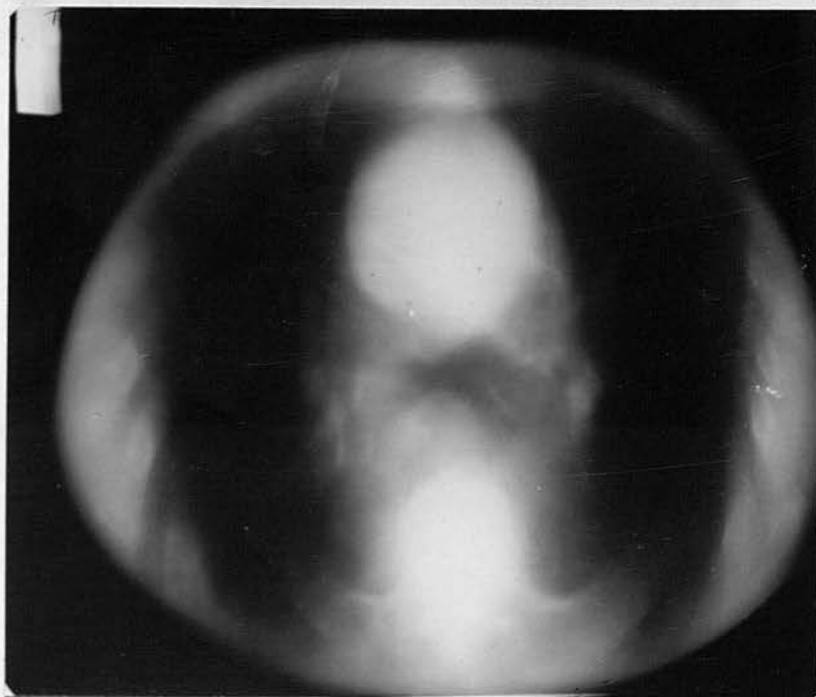


Fig. 47.

Section taken through the cardiac shadow below  
previous section.

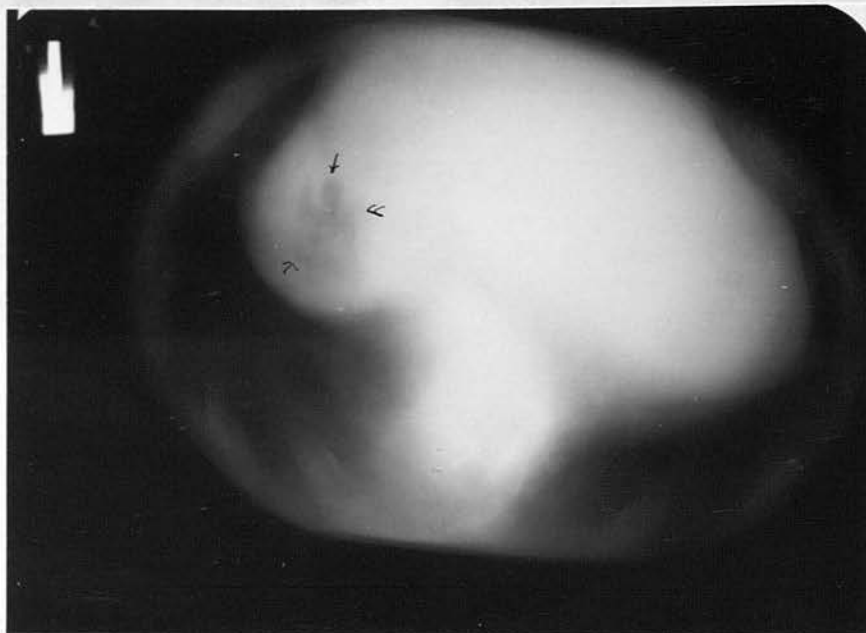


Fig. 48.

Section taken at the level of the diaphragm. Note  
The gas shadow in the stomach.



Case 2.

Aneurysm of the Descending Aorta.

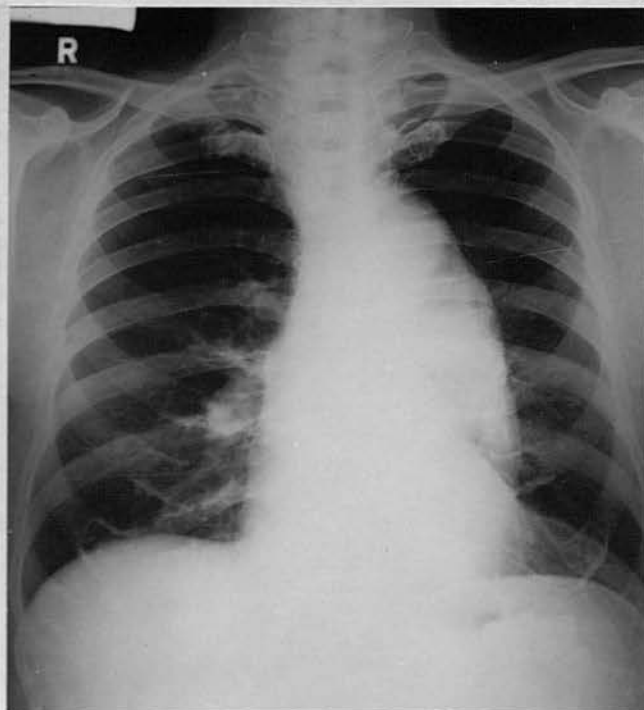


Fig.49.

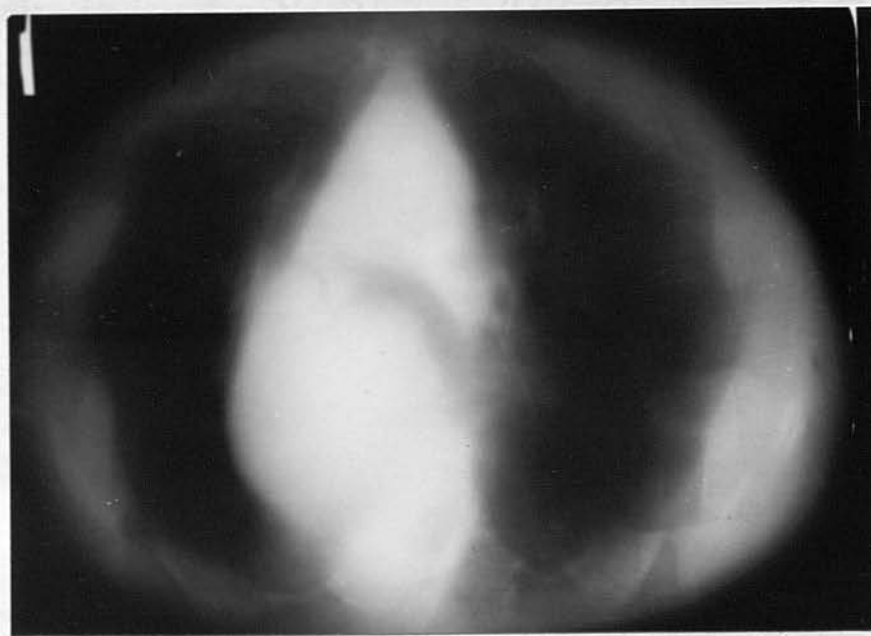


Fig.50.

Horizontal section at the level of the bifurcation  
of the pulmonary artery.

Case.3.

Right Sided Aortic Arch.

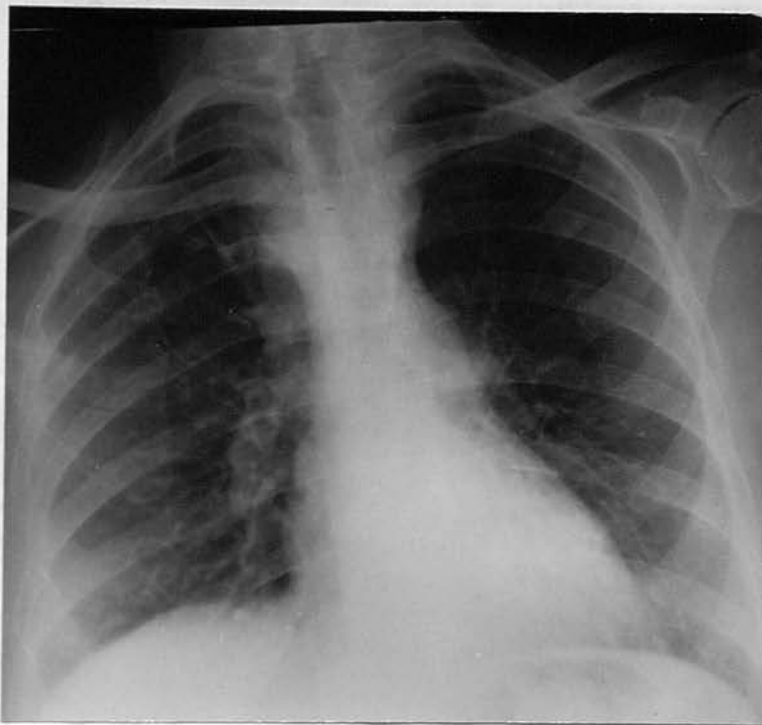


Fig.51.

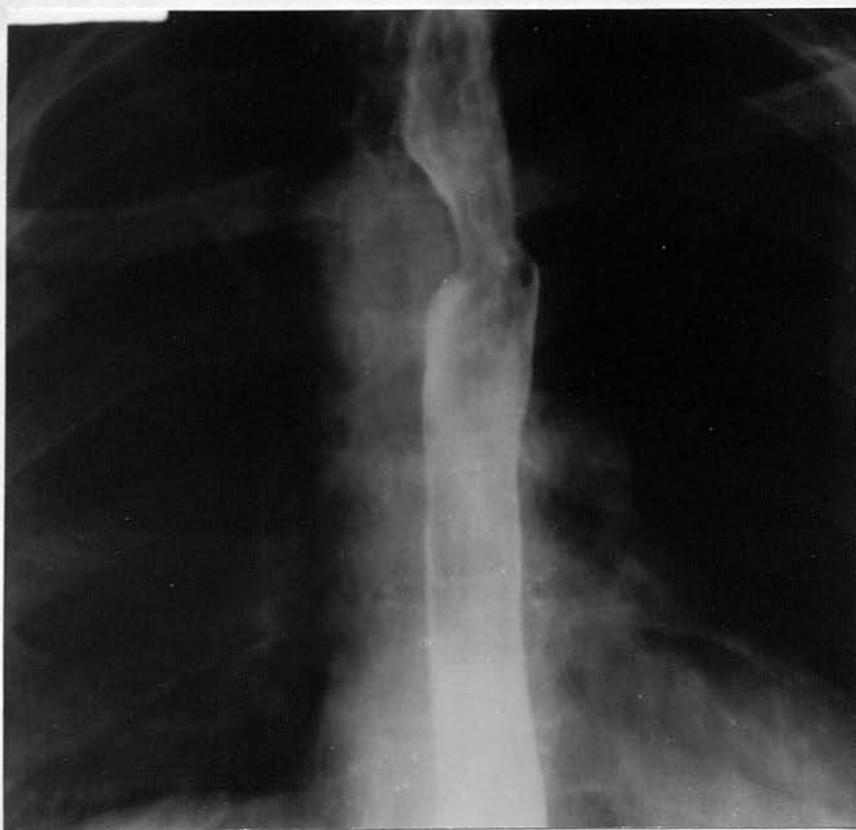


Fig.52.

Right Sided Aortic Arch. (Continued)

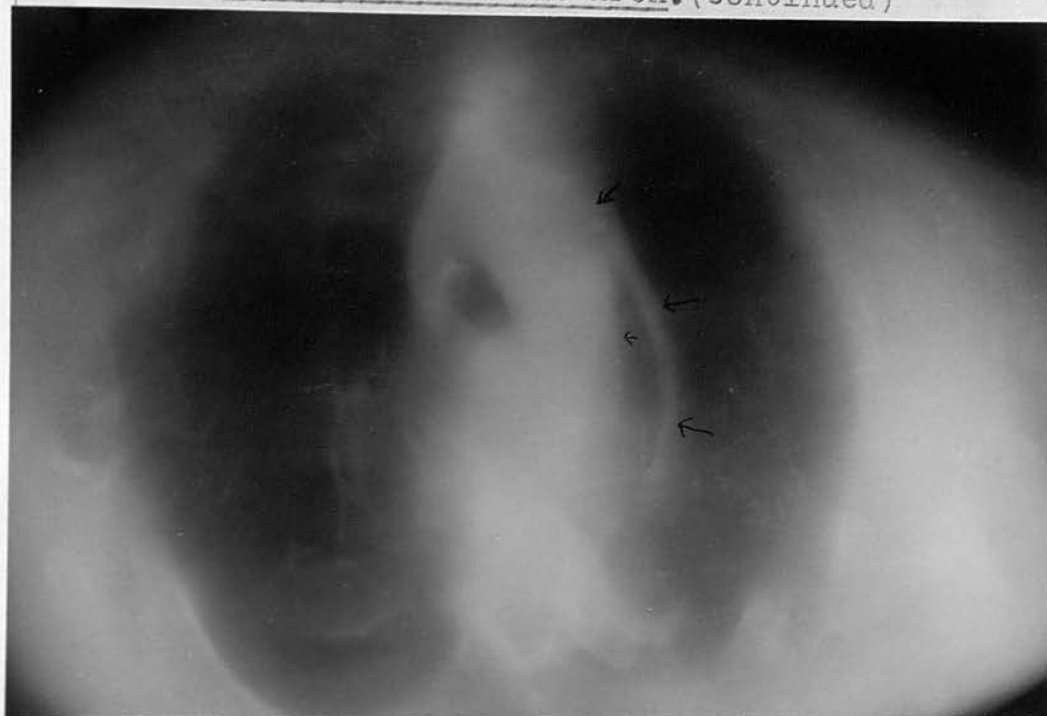


Fig. 53.

Section taken at level of horizontal portion of aortic arch. Note its position and fissure of the azygos lobe..

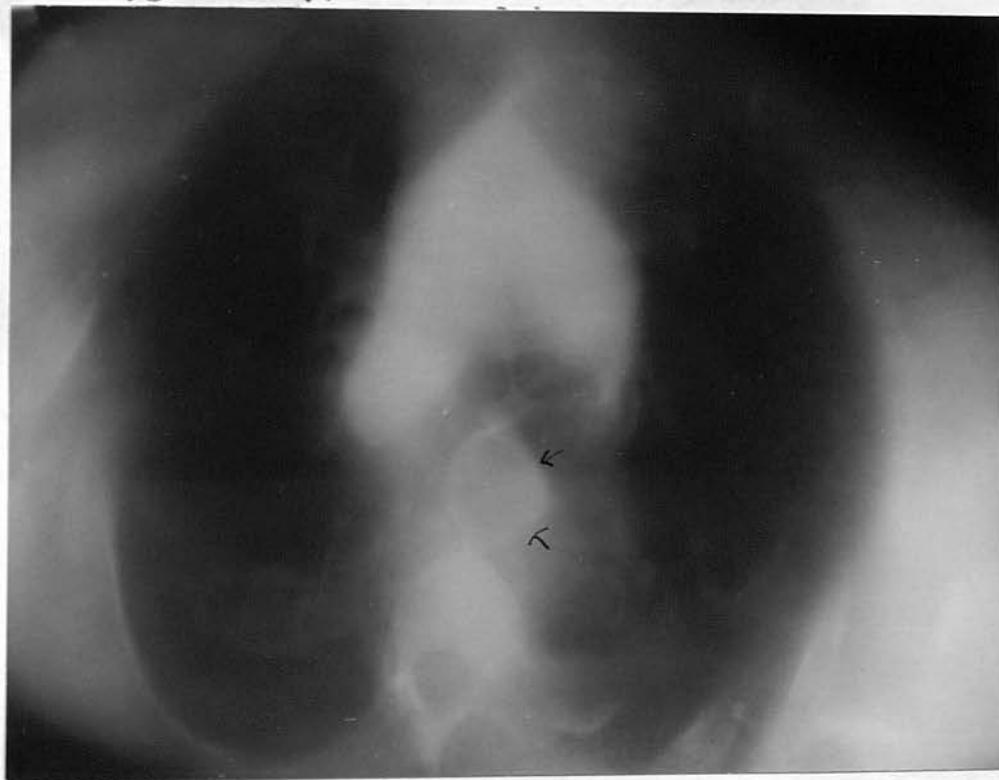


Fig. 54.

Section taken at the level of the carina. Note the descending aorta on the right side.

Double Aortic Arch.

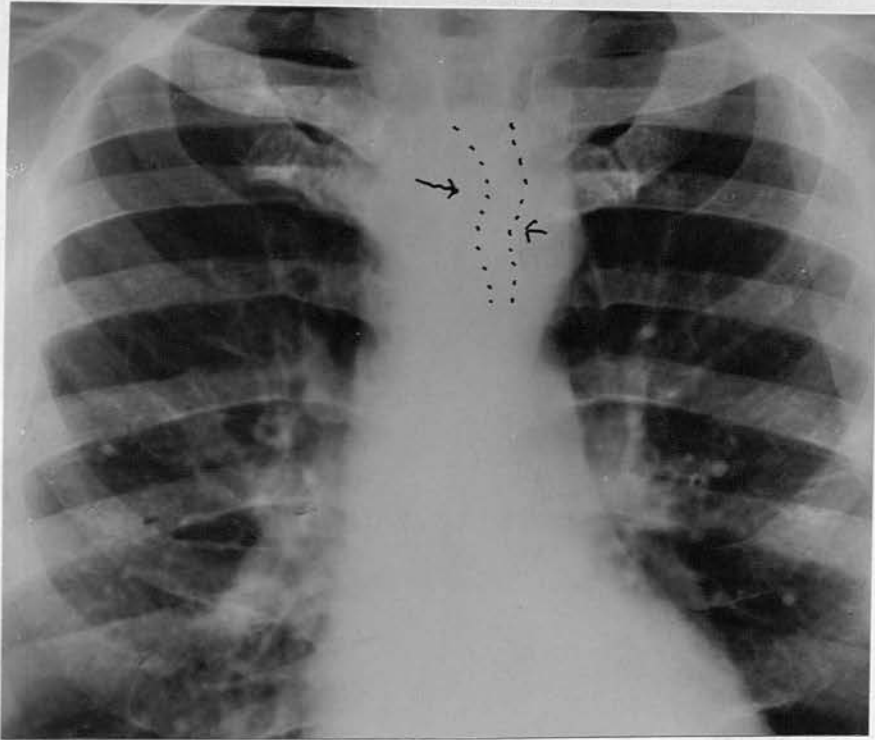


Fig.55.

P.A. view showing indentations in the oesophagus.



Fig.56. 1 of the sternum

Lateral view showing narrowing and anterior displacement of the oesophagus at the level of the vascular ring.

Case 4.

Double Aortic Arch. (Continued)



Fig.57.

Oblique view showing the displacement of the  
oesophagus.

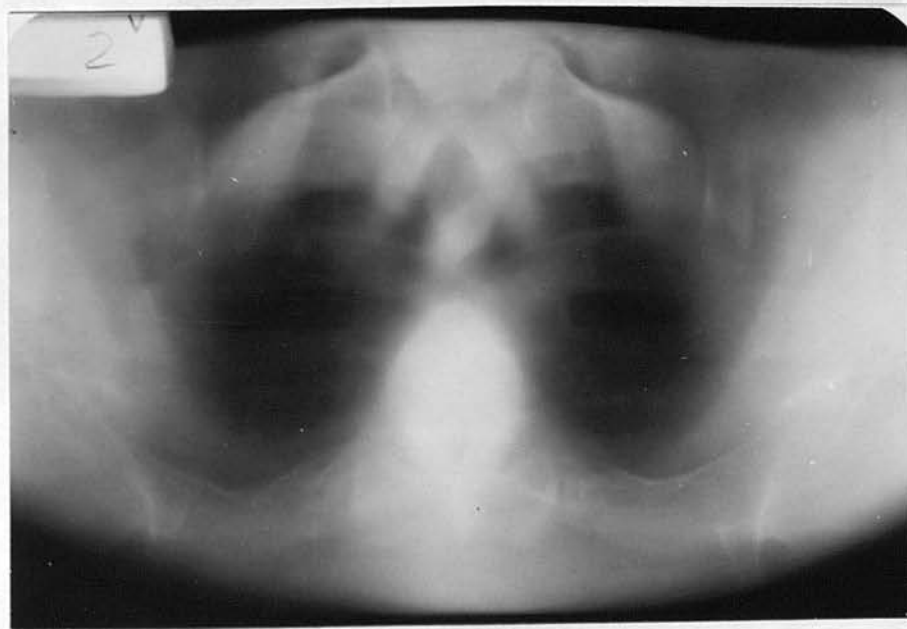


Fig.58.

Horizontal section at the level of the sterno-  
clavicular joints.



Double Aortic Arch. (Continued)



Fig. 59.

Section taken at the level of the first costochondral junction. Note the right branch of the aortic arch. This section is just above the left.



Fig. 60.

Section taken at the level of the vascular ring formed by the right and left branches of the aortic arch and which encircles the oesophagus and trachea.

Case 4.

Double Aortic Arch. (Continued)

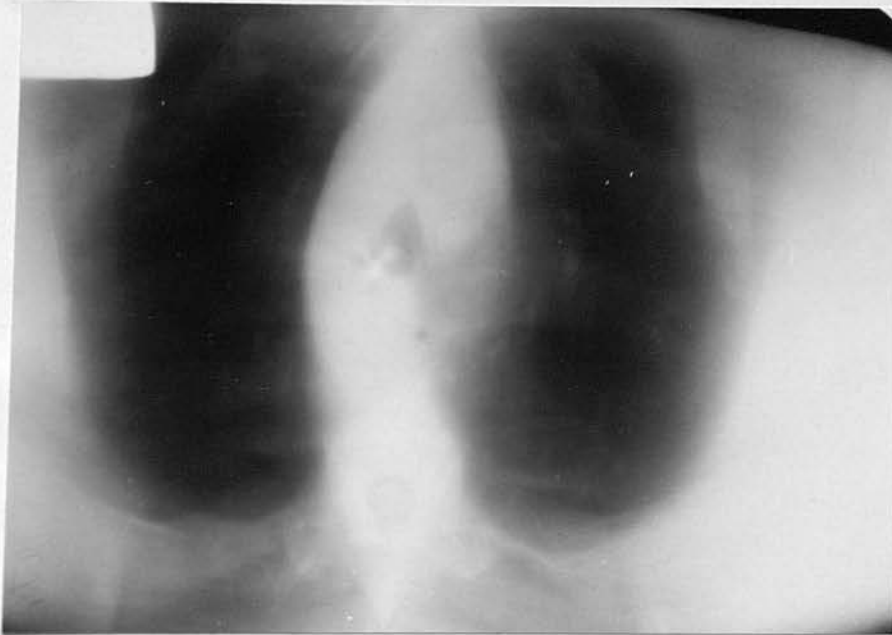


Fig. 61.

Section taken below the previous showing only the left branch of the aorta. An opaque tube is in the oesophagus.



Fig. 62.

Section taken below the previous showing the descending aorta in its normal position.

Case 4.

Double Aortic Arch. (Continued)

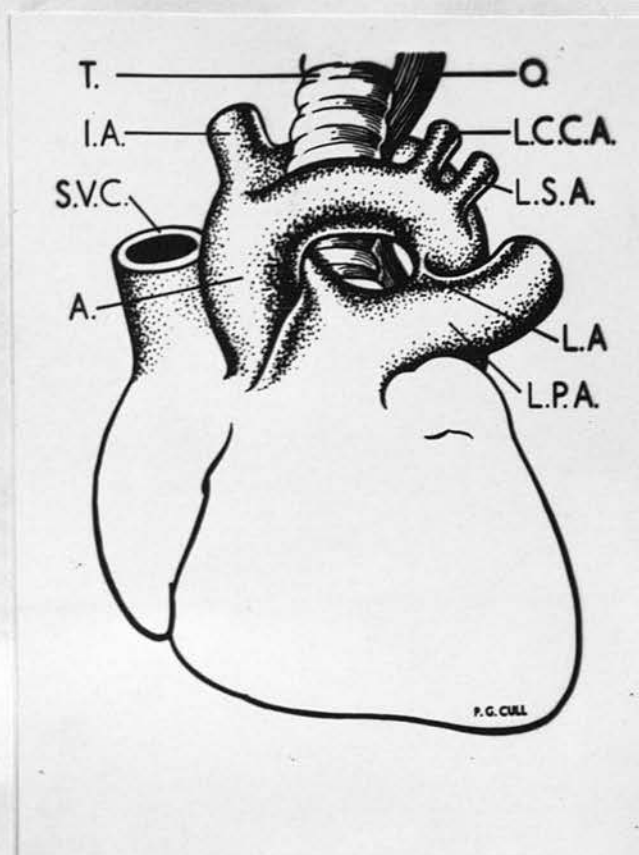


Fig.63.

Probable anatomical arrangement in Case 4.

A. Aorta; I.A. Innominate Artery; L.S.A. Left Subclavian Artery; L.C.C.A. Left Common Carotid Artery; L.P.A. Left Pulmonary Artery; L.A. Ligamentum Arteriosum; O. Oesophagus; T. Trachea. S.V.C. Superior Vena Cava.

Case 5.

Coarctation of the Aorta.

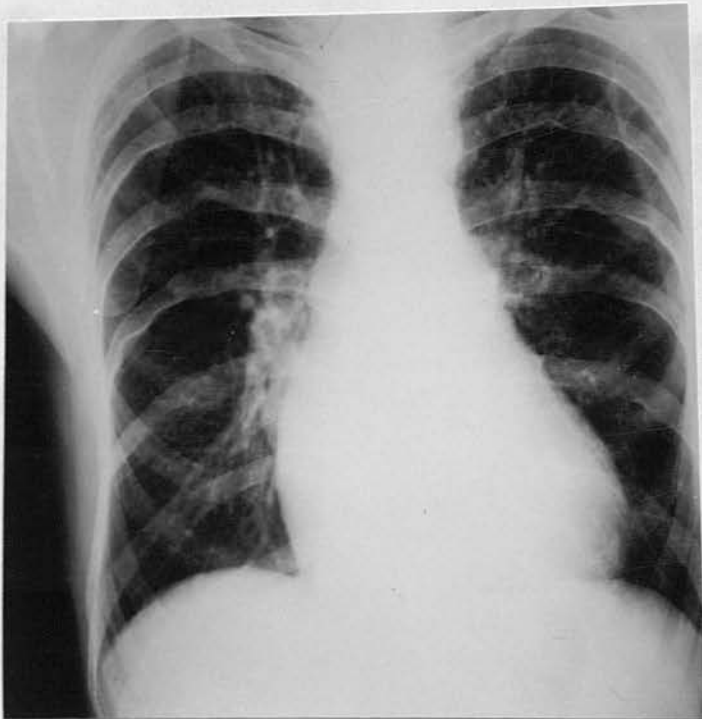


Fig.64.

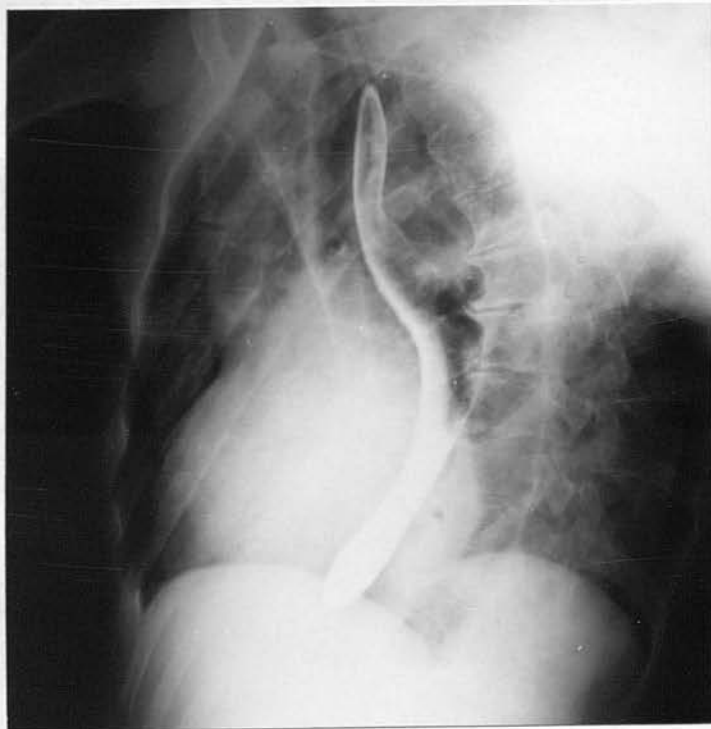


Fig.65.

Note displacement of the oesophagus by  
the dilated segment of the aorta.

Case 5.

Coarctation of the Aorta. (Continued)

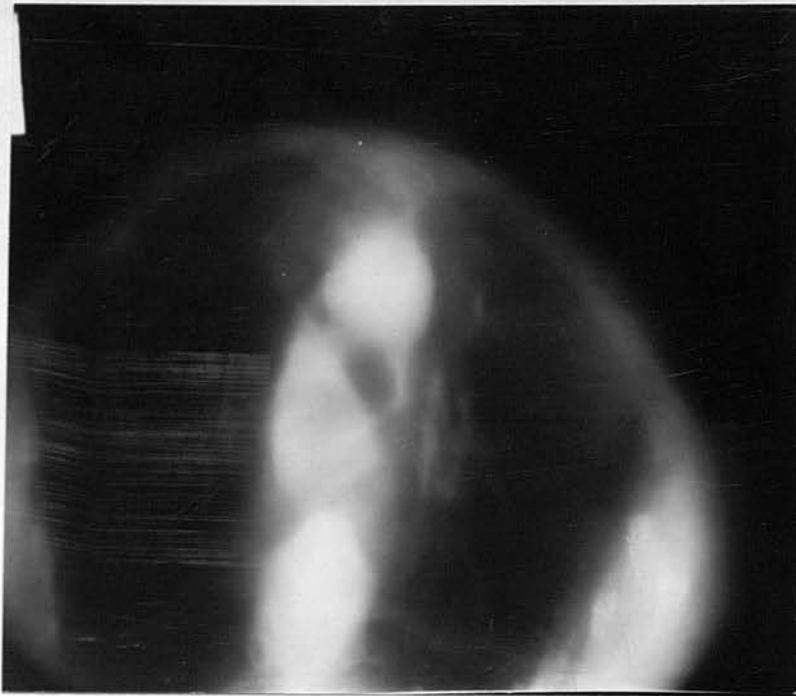


Fig.66.

Section taken at the level of the dilated segment of  
the descending aorta.

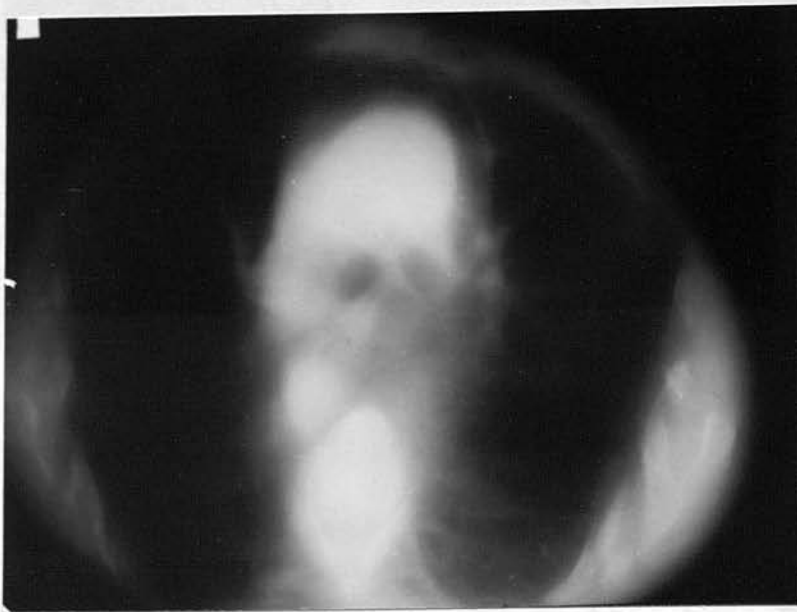


Fig.67.

Section taken at the level of the carina showing a  
normal descending aorta.



Case 6.

Retrosternal Goitre.



Fig.68.

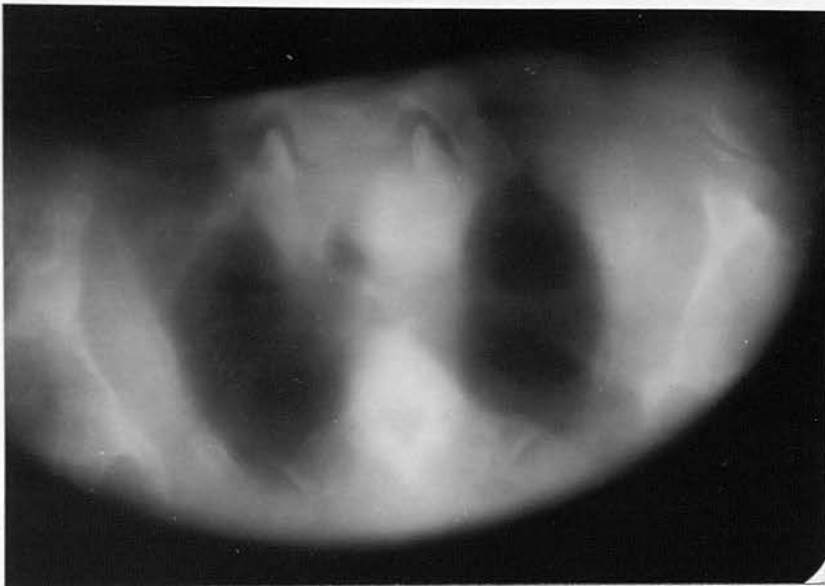


Fig.69.

Horizontal section showing the retrosternal goitre at the level of the sterno-clavicular joints.

Case 6.

Retrosternal Goitre. (Continued)

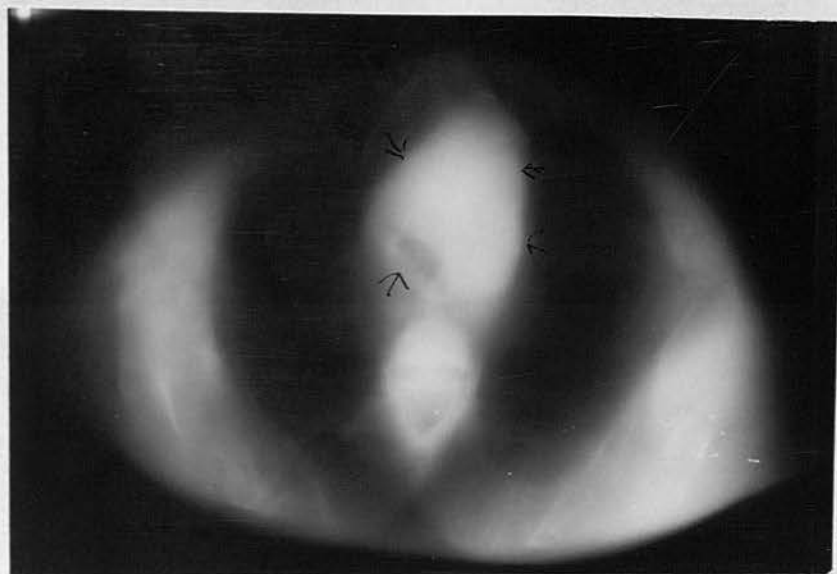


Fig.70.

Section taken just above the aortic arch showing the displacement of the trachea to the left by the thyroid gland.

Case 7.

Bronchogenic Carcinoma.

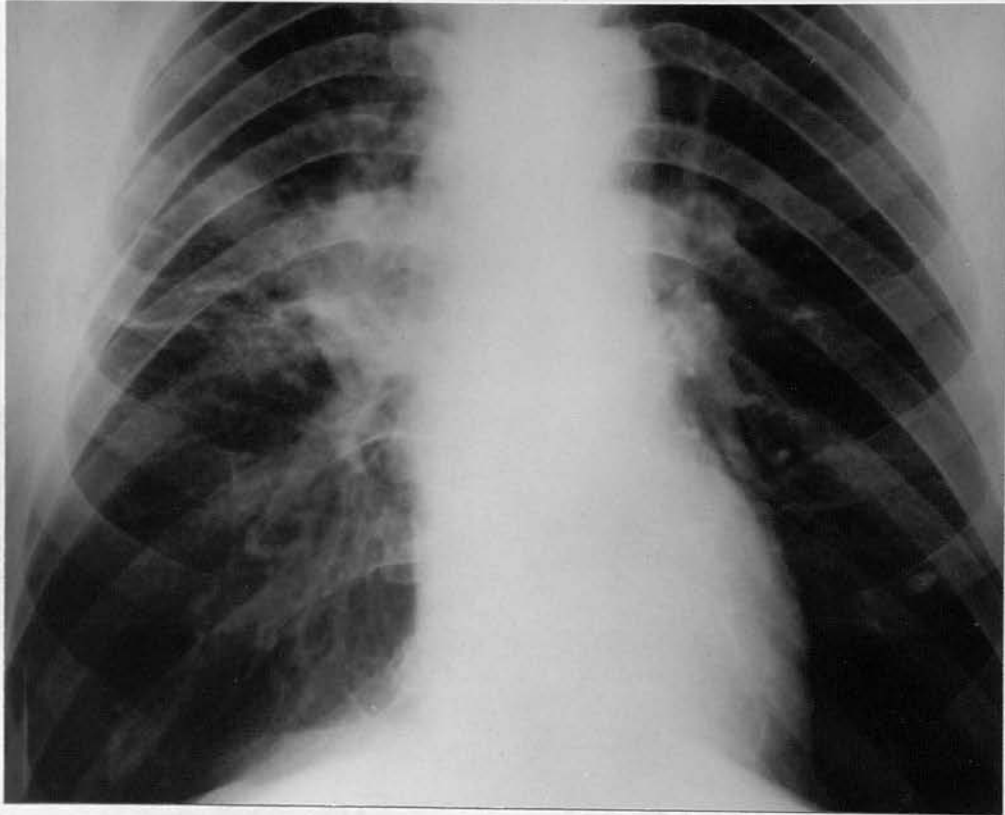


Fig.71



Fig.72.

Vertical Tomograph.

Case 7.

Bronchogenic Carcinoma. (Continued)

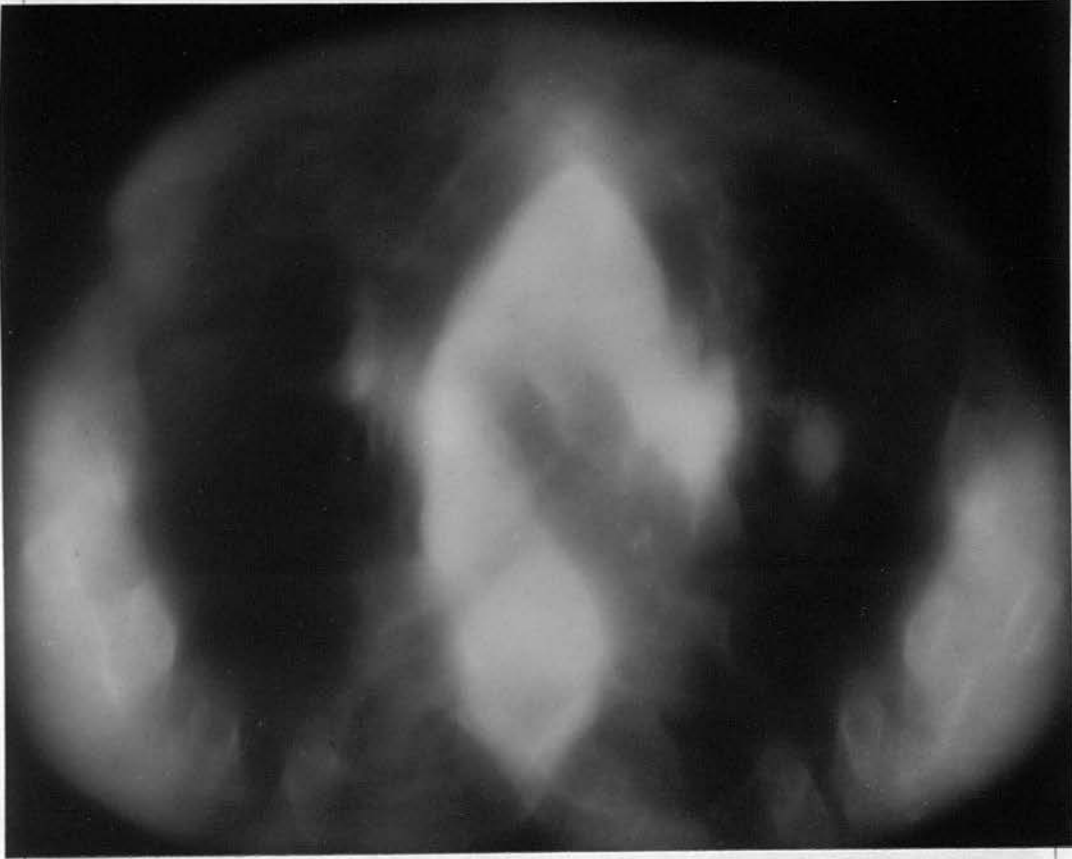


Fig.73.

Horizontal section showing the peripheral lesion in the right lung. Note the enlarged hilar glands.

Bronchogenic Carcinoma.



Fig.74.

Vertical Tomograph.



Case 8.

Bronchogenic Carcinoma.(Continued)

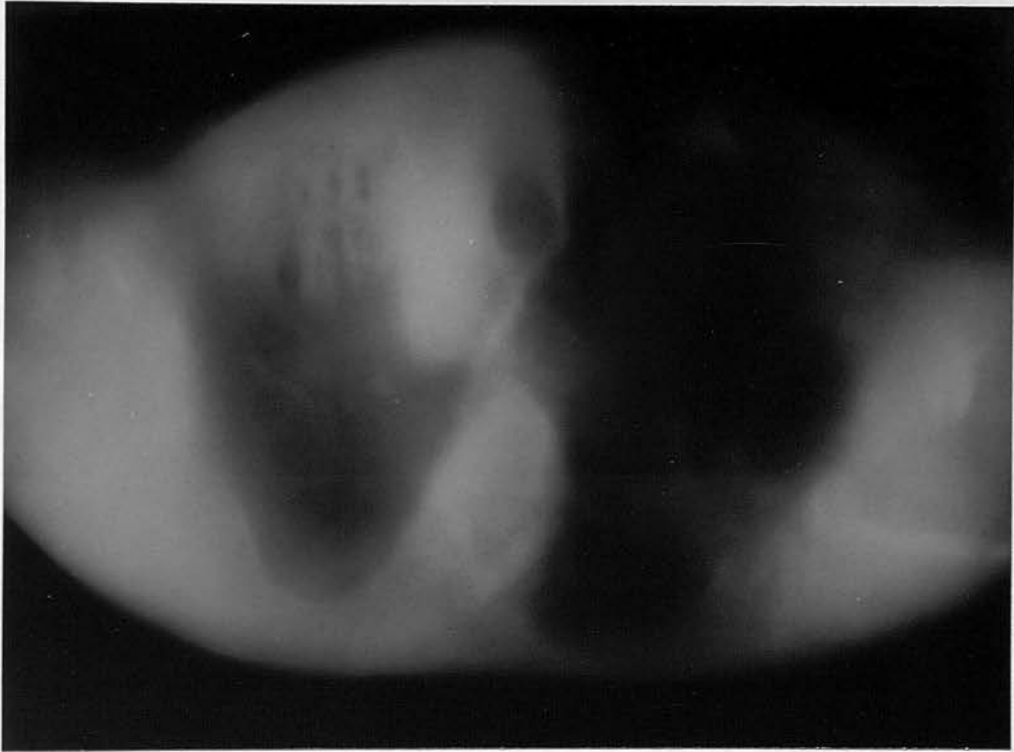


Fig.75.

Section at the level of the aortic arch. Note the dilated bronchi in the collapsed antero-lateral segment of the left upper lobe.



Fig.76.

Section along the occluded upper lobe bronchus.

Case 9.

Pulmonary Cavity.

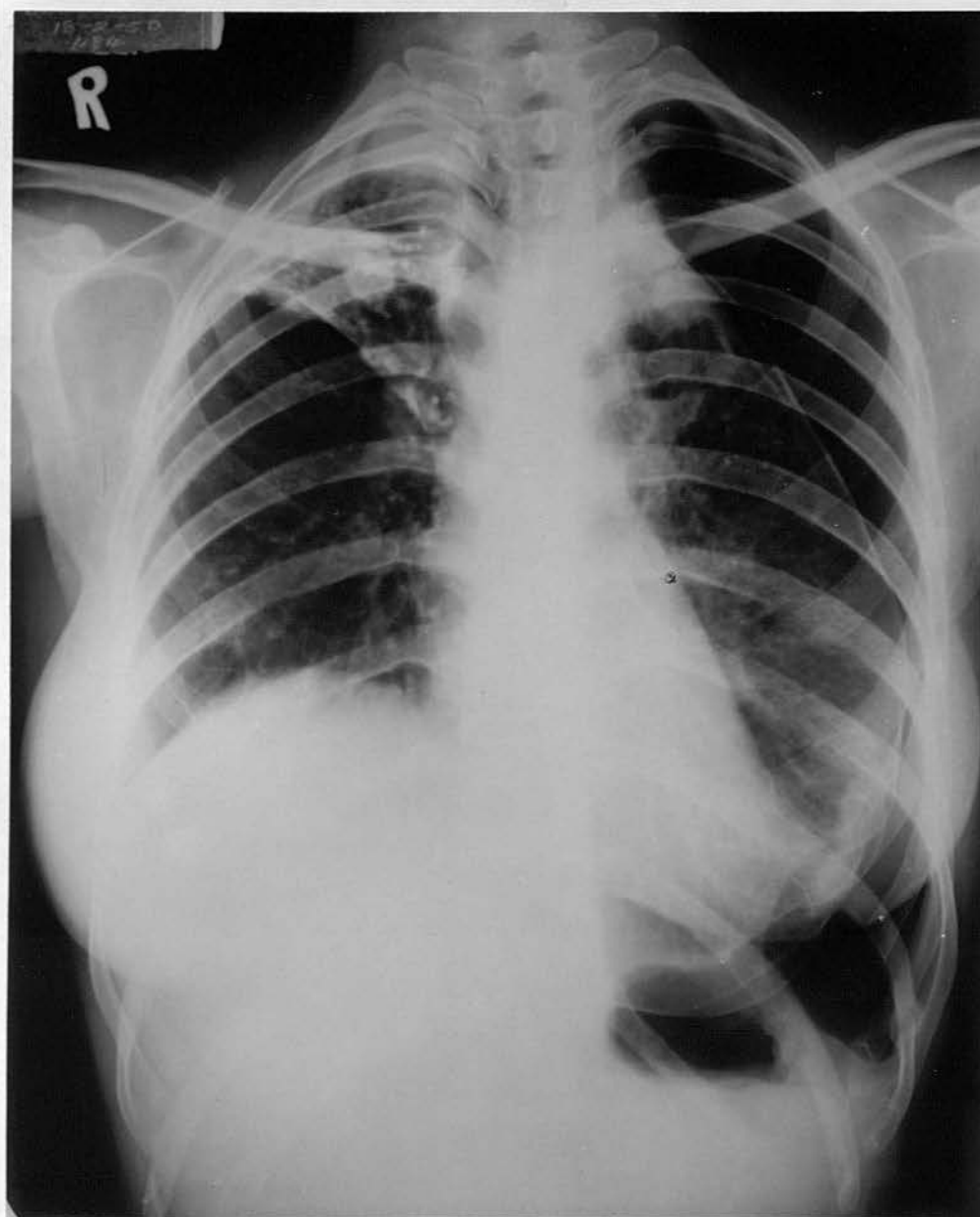


Fig 77.

Case 9.

Pulmonary Cavity.

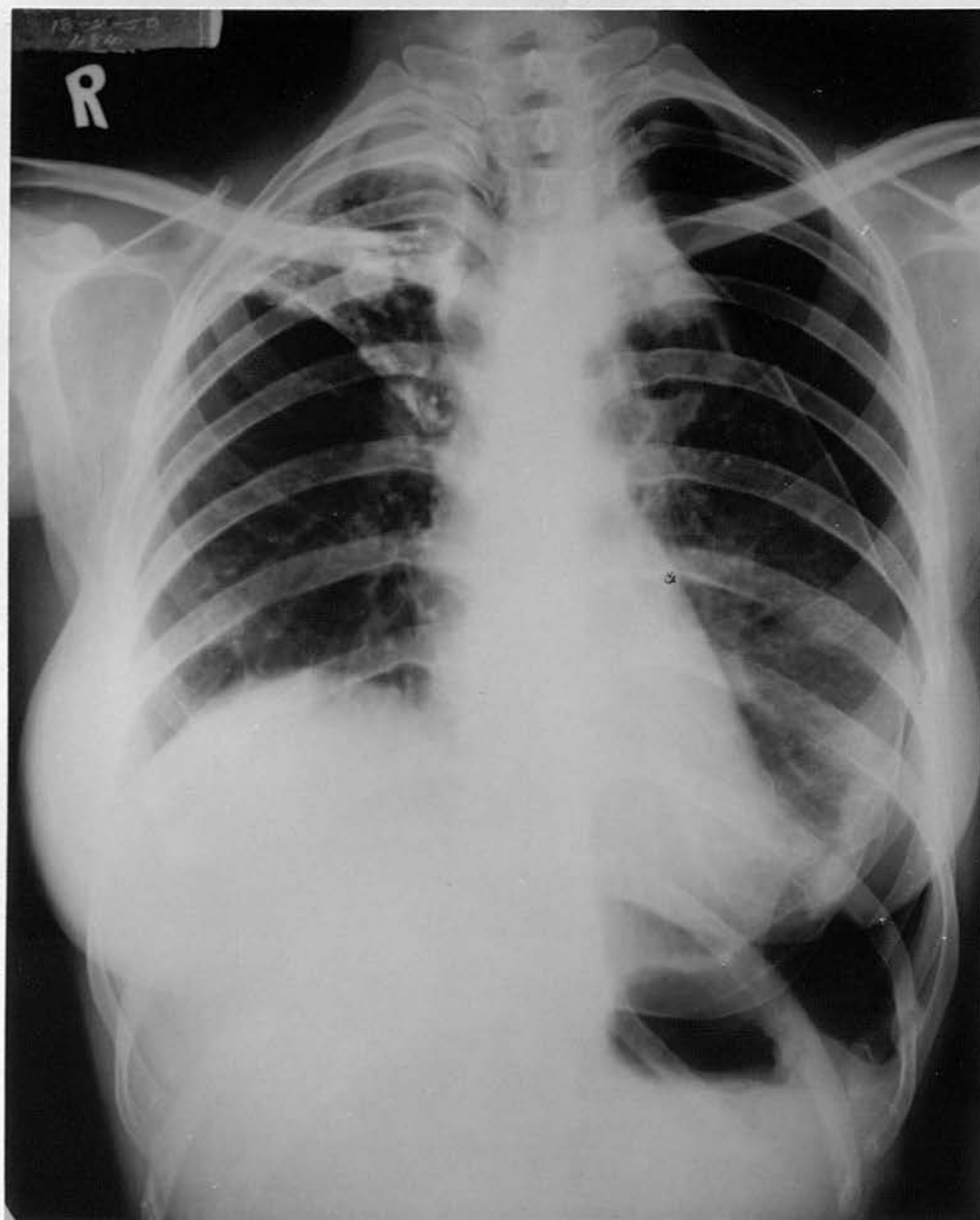


Fig 77.

Pulmonary Cavity. (Continued)



Fig. 78.

Horizontal section showing the cavity within the collapsed left lung. Note the displacement of the carina to the left.